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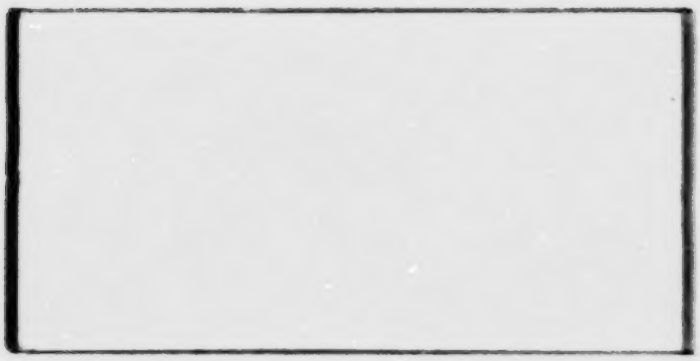

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BRUCE GS 'B' FISH DIVERSION TEST PROGRAM PICKERING GS, 1982 AND SUMMARY

Report Number 84-44-K

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ABSTRACT

The response of rainbow smelt and alewife to a rope net barrier and a rope net barrier illuminated with unsynchronized strobe lights and the response of alewife to a rope net - synchronized strobe barrier were evaluated in a field situation at Pickering GS. One hundred and eighty-one test replicates, 2 to 23 hours duration, were performed throughout the study period. Smelt displayed a distinct avoidance of the experimental and control structures during rope net replicates, but were attracted to the strobe lights during unsynchronized strobe light replicates. This attraction was attributed to the failure of the unsynchronized strobe units to produce a typical strobe light effect. Alewife displayed a significant avoidance of the rope net. Alewife passage was reduced 63% during daylight replicates, 89% during night replicates and 79% during all light conditions. The reduction in alewife passage could not be attributed to any monitored variable. Alewife were attracted to the unsynchronized strobe lights which produced a nearly continuous light source. There was no significant difference between experimental and control results during synchronized strobe light-rope net replicates. The rope net barrier appears to be a promising method for excluding alewife. It is probable that the rope net barrier would reduce the intake of smelt. The rope net barrier should be considered as an alternative method for diverting fish at a velocity cap.

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Table of Contents

	Page
1.0) Introduction	1
2.0) Materials and Methods	3
2.1 System Design	3
i) Diversion System	3
ii) Fish Occurrence and Behaviour Studies	9
2.2 Experimental Design	9
i) Diversion System	9
ii) Fish Occurrence and Behaviour Studies	14
3.0) Results	14
3.1) Smelt Tests	14
i) Rope net barrier alone	14
ii) Rope net - unsynchronized strobe lights	22
3.2) Alewife Tests	25
i) Rope net alone	25
ii) Rope net - unsynchronized strobe lights	29
iii) Rope net - synchronized strobe lights	30
4.0 Discussion	31
4.1) Smelt Tests	33
i) Rope net alone	33
ii) Rope net - unsynchronized strobe light	34
4.2) Alewife Tests	36
i) Rope net alone	36
ii) Rope net - unsynchronized strobe light	37
iii) Rope net - synchronized strobe light	37
5.0) Conclusions	38

6.0) Summary 38

7.0) Recommendations 39

References 40

Appendices 42

Distribution last page

LIST OF FIGURES

Figures		Page
2.1-1	FISH DIVERSION SYSTEM STUDY LOCATION PICKERING DIVERSION STUDY, 1982	4
2.1-2	TOP VIEW OF ONE EXPERIMENTAL APPARATUS PILINGS, COLLECTION NET, AND STROBE LIGHTS PICKERING DIVERSION STUDY, 1982	5
2.1-3	SIDE VIEW OF TEST APPARATUS SHOWING STROBE LIGHT PLACEMENT AND GILL NET FRAME (RAISED) PICKERING DIVERSION STUDY, 1982	6
2.1-4	GILL NET FRAME, GUIDES AND SUPPORT PICKERING DIVERSION STUDY, 1982	7
2.1-5	PICKERING FISH DIVERSION ACOUSTIC SYSTEM LOCATION, PICKERING DIVERSION STUDY, 1982	10

LIST OF TABLES

Tables		Page
2.2-1	PICKERING DIVERSION REPLICATE SCHEDULE PICKERING DIVERSION STUDY, 1982	12
2.2-2	ACOUSTIC MONITORING PROGRAM TEST SUMMARY PICKERING DIVERSION STUDY, 1982	15
3.0-1	AVERAGE CATCHES PER UNIT EFFORT (2 HR) IN CONTROL AND EXPERIMENTAL FRAME NETS PICKERING DIVERSION STUDY, 1982	16
3.0-2	TOTAL MEAN SMELT (LAKE FISH) CATCH PER UNIT EFFORT, PICKERING DIVERSION STUDY, 1982	17
3.0-3	TOTAL MEAN ALEWIFE (LAKE FISH) CATCH PER UNIT EFFORT, PICKERING DIVERSION STUDY, 1982	18
3.0-4	RANGE OF EXPERIMENTAL AND CONTROL WATER TEMPERATURE, TURBIDITY AND SECCHI DISC MEASUREMENTS, PICKERING DIVERSION STUDY, 1982	19
3.0-5	EAST AND WEST STRUCTURE TEMPERATURE (^{o}C) ANOVA RESULTS, PICKERING DIVERSION STUDY, 1982	20
3.0-6	EAST AND WEST STRUCTURE TURBIDITY (NTU) ANOVA RESULTS, PICKERING DIVERSION STUDY, 1982	21
3.1-1	EXPERIMENTAL VS CONTROL FRAME NET CATCH PER UNIT EFFORT (2 HR) ANALYSIS, PICKERING DIVERSION STUDY, 1982	23
3.1-2	EXPERIMENTAL VS CONTROL WING NET CATCH PER UNIT EFFORT (2HR) ANALYSIS, PICKERING DIVERSION STUDY 1982	24
3.2-1	DISTRIBUTION OF FISH (%OF ECHOES) RELATIVE TO DISTANCE FROM THE BARRIER PICKERING DIVERSION STUDY, 1982	27
3.2-2	SUMMARY OF OBSERVED FISH TRAJECTORY RELATIVE TO THE DIVERSION STRUCTURE FROM ACOUSTIC MONITORING PICKERING DIVERSION STUDY, 1982	28
3.2-3	SUMMARY OF FISH TRAJECTORY RELATIVE TO SYNCHRONIZED STROBE LIGHT - ROPE NET BARRIER FROM ACOUSTIC MONITORING, PICKERING DIVERSION STUDY, 1982	32
4.2-1	ROPE NET ALONE ALEWIFE PASSAGE PICKERING DIVERSION STUDY, 1982	36

LIST OF APPENDICES

		Page
Appendix A	DIVERSION SYSTEM STRUCTURE DESIGN PICKERING DIVERSION STUDY, 1982	42
Appendix B	FISH CATCH (2 HR CUE) DATA SUMMARY PICKERING DIVERSION STUDY, 1982	43
Appendix C	WATER TEMPERATURE (^{O}C), TURBIDITY (NTU), AND SECCHI DISC (M) DATA SUMMARY PICKERING DIVERSION STUDY	47
Appendix D	STROBE LIGHT OPERATION PICKERING DIVERSION STUDY, 1982	51
Appendix E	STROBE LAMP DURATION (HOURS) PICKERING DIVERSION STRUCTURE, 1982	52
Appendix F	ACOUSTIC MONITORING STUDY QUALITATIVE FISH DATA, PICKERING DIVERSION STUDY, 1982	53

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To Dr. W.R. Effer
Manager, Design & Development

Bruce GS 'B' Fish Diversion Test Program
Pickering GS, 1982
and Summary

1.0 Introduction

When the Ontario Ministry of Environment (OMOE) granted Ontario Hydro the permit to take water at Bruce GS 'B', Ontario Hydro agreed to try to develop a workable fish diversion barrier for possible installation at Bruce GS 'B' if the barrier was proven successful in preventing fish from entering intake structures (OMOE Permit to Take Water No. 79-P-1110, issued to Ontario Hydro for Bruce GS 'B', August 13, 1979). Environmental Studies and Assessments (ES&A), Design and Development Division, subsequently requested Biological Research Section to perform laboratory and field studies of behavioural fish barriers suitable for retrofit to velocity cap intakes. Fish (alewife, gizzard shad and smelt) response to chains, chain rope nets and wire fences alone and in combination with strobe light was investigated in the laboratory at different current velocities and ambient light levels (OHRD Report 79-104-K, 80-82-K, 80-156-K, 80-238-K and 81-190-K). These investigations indicated:

a) barriers with a vertical and horizontal component (square) were more effective than barriers consisting only of a vertical component
b) larger diameter barrier components were more effective in diverting fish than smaller diameter components
c) barrier effectiveness increased with a decrease in barrier spacing
d) barrier efficiency increased significantly at night when illuminated with strobe light.

During these studies alewife, gizzard shad and smelt exhibited significant avoidance of 10 and 20 cm (4 and 8 in) square spaced chain rope net barriers illuminated by 1 to 4 strobe lights. The field evaluation of a 15 cm (6 in) square spaced chain rope net barrier illuminated by strobe lights was therefore recommended at the conclusion of the laboratory studies (OHRD Report 81-190-K). Following the laboratory studies it was decided to test the effectiveness of a rope net barrier alone (15 cm square), strobe lights alone and the rope net barrier illuminated by the strobe lights in a field situation.

The initial field investigations were to be conducted at the Bruce GS 'A' intake structure. However the high cost of installing strobe lights at Bruce GS 'A' and insufficient system design time necessitated the selection of an alternative test site. It was decided to test the pilot diversion system at Pickering GS and if successful the system would be field tested at the Bruce GS 'B' intake structure. This plan was acceptable to the OMOE and Ontario Ministry of Natural Resources (OMNR, minutes of Dec. 17, 1980 meeting, dated Feb. 23, 1981). The Pickering test site met the requirements of an open lake site with an acceptable current velocity (0.1 - 0.3 m.s-1), depth (approx. 6 m) and minimal discharge recirculation. Pickering fish density records suggested that sufficient alewife and smelt fish stocks were present in the vicinity of the test site to evaluate the effectiveness of the fish diversion barrier systems (OHNGD Report RMEP-IR-07000-2, RMEP-IR-07000-4, OHRD Report 78 - 475 - K, 78 - 358 - K). The selection of the Pickering site also simplified labour and material logistics.

A pilot fish diversion field test structure was designed by Bruce Engineering, Biological Research and ES&A in 1980 and 1981. The system was installed in May 1981 at Pickering GS 70 m (230 ft.) south of the intake groins (OHRD Report C82-19-K). The fish diversion system consisted of two duplicate structures permitting operation of either structure in an experimental or control mode. System design permitted the evaluation of the effectiveness of rope nets (15 cm square spacing) or strobe lights alone or in combination with each other in diverting fish. The evaluation of barrier effectiveness was to be based primarily upon the number of fish caught in hoop nets at the cod end of the collecting nets situated behind (north of) the diversion systems. Field fish diversion studies (rope net alone, rope net - unsynchronized strobe lights) with alewife were performed in 1981. No studies were conducted with smelt in 1981 since insufficient smelt stocks were in the vicinity of the diversion system when installation was completed. Peak smelt occurrence was in April and early May, (OHNGD Report RMEP-IR-07000-2, RMEP-IR-07000-4). Overall results were insufficient to meet the study objective which was to assess the effectiveness of each of the three diversion systems in diverting fish in an open lake situation (OHRD Report C82 - 19 - K). Strobe light circuit malfunctions, strobe light lamp failure, underwater strobe housing leakage and low alewife densities in the test vicinity contributed to the study failure. Evaluation of the fish diversion barrier systems was not possible due to the low fish catch in the hoop nets at the cod end of the collection nets, the high degree of variability in fish catch location (control vs experimental nets) and the low number of test replicates. The strobe light circuit malfunctions and strobe housing leakage problems were corrected. Strobe lamp failure, related to inferior lamp quality, could not be remedied. However, frequent replacement of strobe lamps would permit further studies to proceed (OHRD Report 82 - 177 - H). Biological Research designed a gill net fish collection system to improve fish capture and increase efficiency and crew safety. Bruce Engineering, ES&A and Biological Research therefore decided

to proceed with a 1982 study to try to develop a workable fish diversion barrier (Minutes of Nov. 26, 1981 meeting, dated Nov. 30, 1981, File Number 962-NK29-07263).

Subsequent to the 1982 study commencement, ES&A requested Biological Research to provide a qualitative assessment of:

a) fish occurrence in the vicinity of the diversion structures
b) movement of fish approaching and in the vicinity of the diversion structures
c) fish avoidance of the diversion systems or structure.

It was believed that this information would be beneficial in the interpretation of the diversion study results. Attempts were made to obtain this information by using the acoustic fish census system (OHRD Report 79-87-K) and underwater video cameras.

2.0 Materials and Methods

2.1 System Design

i) Diversion System

The rope net and strobe light barrier systems were tested in an open lake situation 70 m south of the Pickering intake groins (Fig. 2.1-1). The test structures were similar in design to the modified 1981 diversion test structures (OHRD Report C82 - 19 - K). Detailed Design and Construction Branch Drawings of the system design are listed in Appendix A.

The duplicate support structures of each apparatus consisted of nine 0.3 m (12 in) pilings arranged in three rows as depicted in Figure 2.1-2. The three southern pilings of each test apparatus supported the rope net barriers (Fig. 2.1-3). The middle row of pilings (4 per test apparatus) each supported 3 strobe lights in underwater housings. The north pilings (2 per structure) supported the fish collecting apparatus (frame nets) (Fig. 2.1-4).

The rope net barriers consisted of two 3.9 m (13 ft) wide by 6.7 m (22 ft) high panels constructed of 2.5 cm (1 in) nylon rope. The vertical components of the barriers were comprised of 2 fused ropes presenting a 5 cm (2 in) barrier surface. A single horizontal was attached to the vertical components to produce a 15 cm (6 in) square spacing between ropes. The rope nets could be raised or lowered as required with a boat and SCUBA divers. When lowered the rope nets projected approximately 1 m (3.3 ft) above the lake bed.

The twelve strobe lights in sealed underwater housings were arranged on the 4 central pilings of each structure in a 3 by 4 matrix with vertical and horizontal spacings of 1.4 m (4.5 ft) and 2.1 m (7.0 ft) respectively between strobes (Fig. 2.1-2,3). The upper row of strobe lights was 1.4 m (4.5 ft) below lake level while the lower row of strobe lights was 0.9 m (3.0 ft) above the lake bed. Each strobe light housing was situated 2.0 m

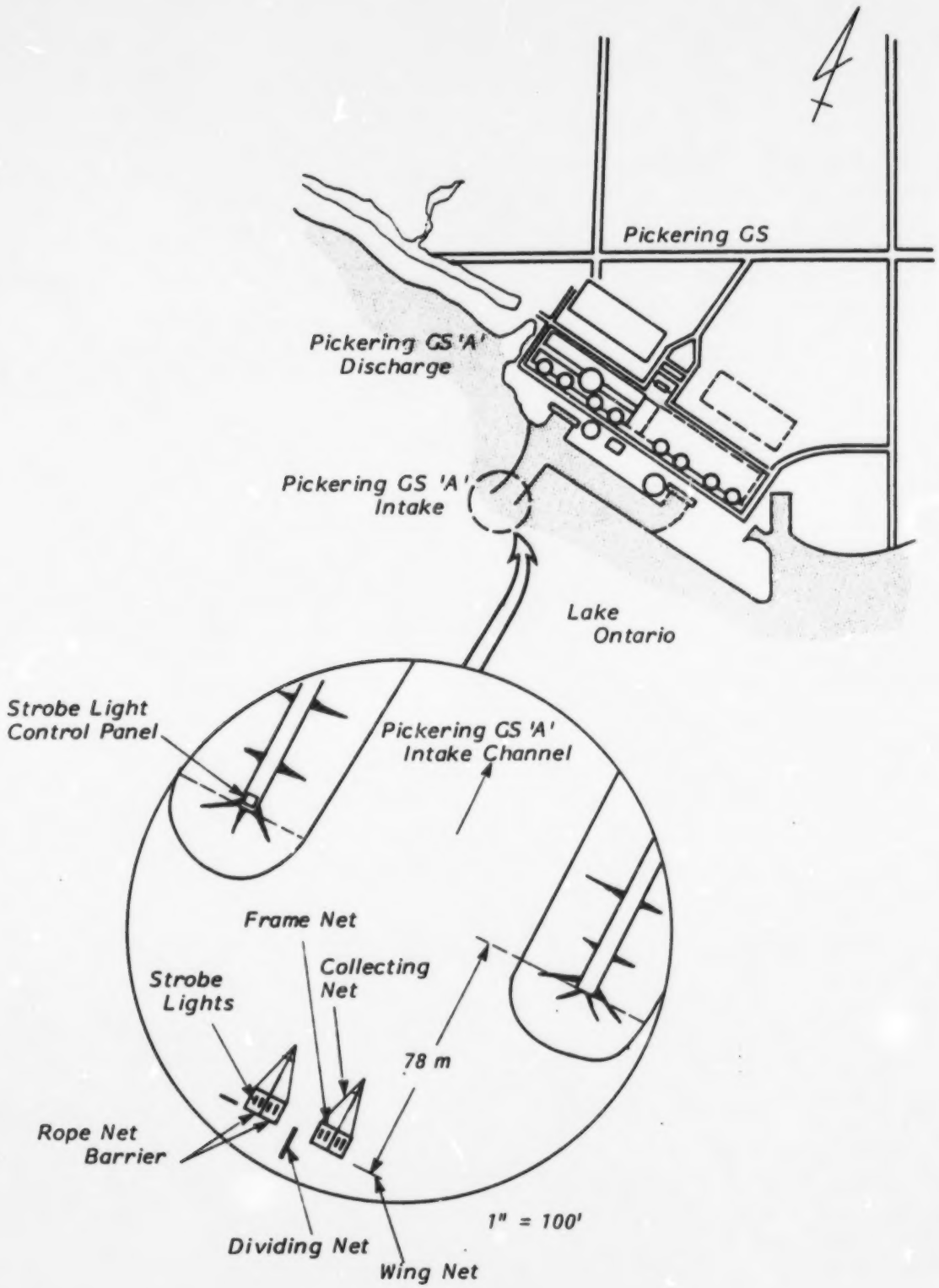

FIGURE 2.1-1

FISH DIVERSION SYSTEM STUDY LOCATION
PICKERING DIVERSION STUDY, 1982

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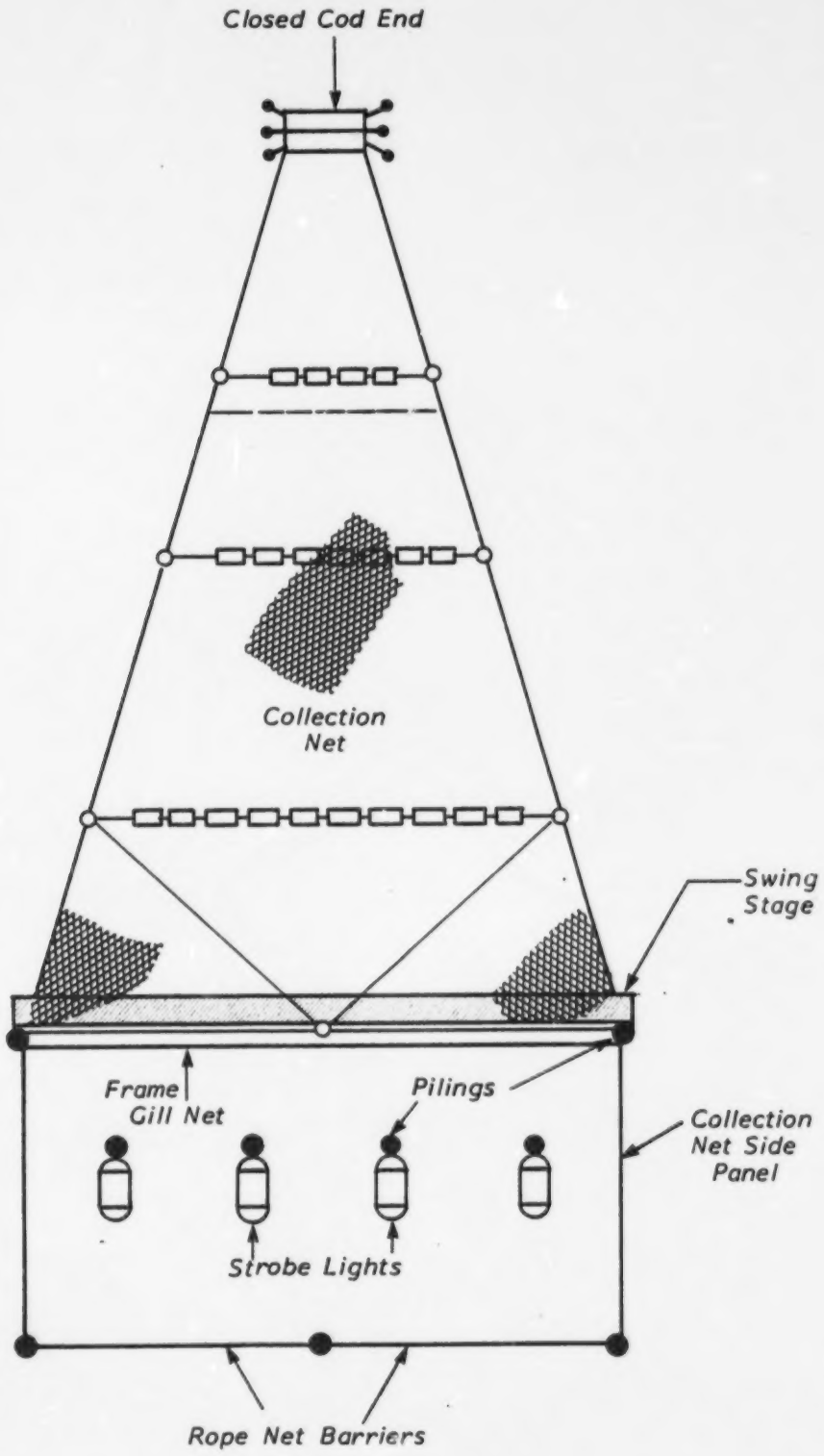

FIGURE 2.1-2

TOP VIEW OF ONE EXPERIMENTAL APPARATUS
PILINGS, COLLECTION NET AND STROBE LIGHTS
PICKERING DIVERSON STUDY 1982
(Anchor system not shown for clarity)

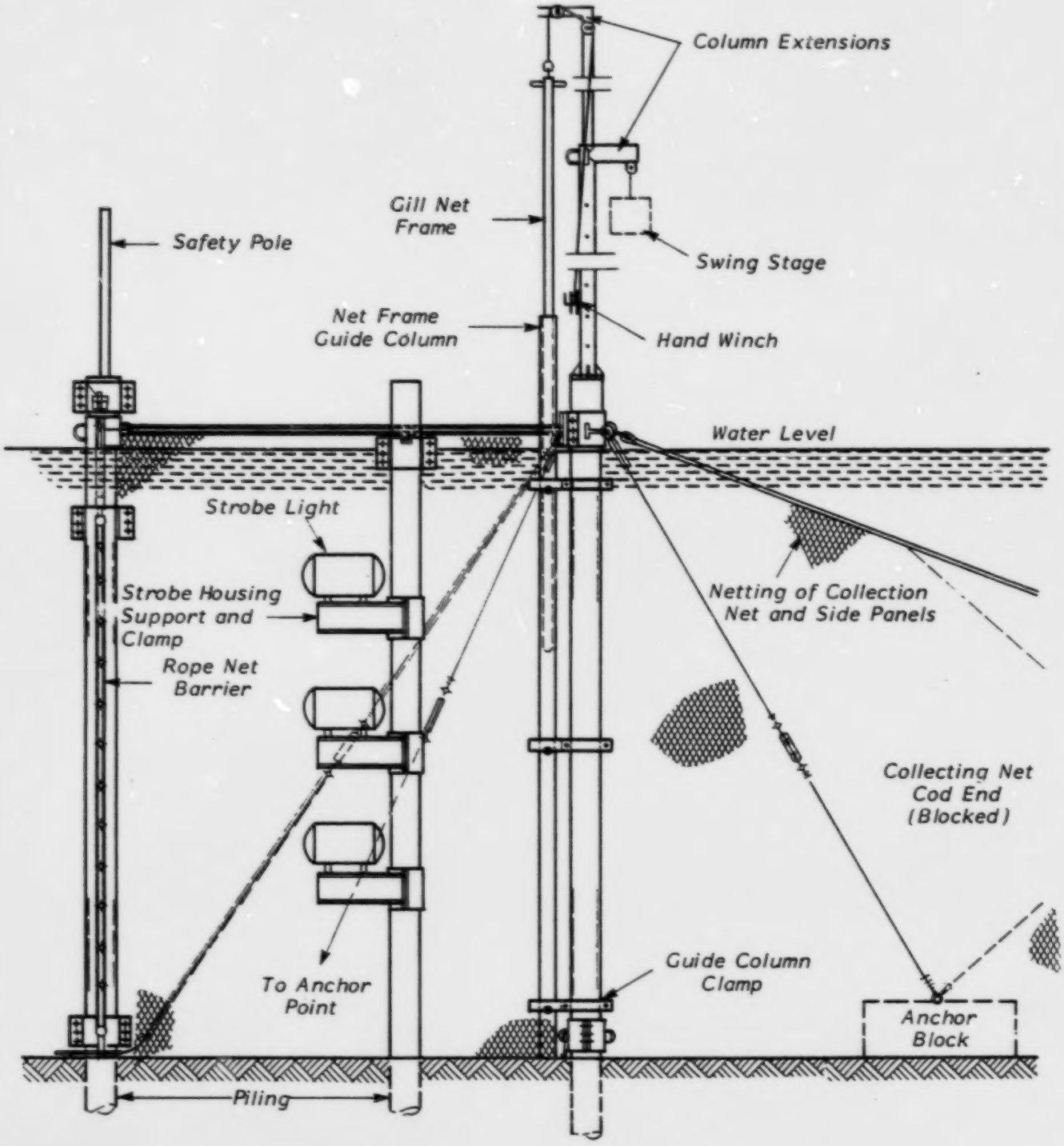

FIGURE 2.1-3

SIDE VIEW OF TEST APPARATUS SHOWING STROBE LIGHT PLACEMENT AND GILL NET FRAME (RAISED) PICKERING DIVERSION STUDY 1982

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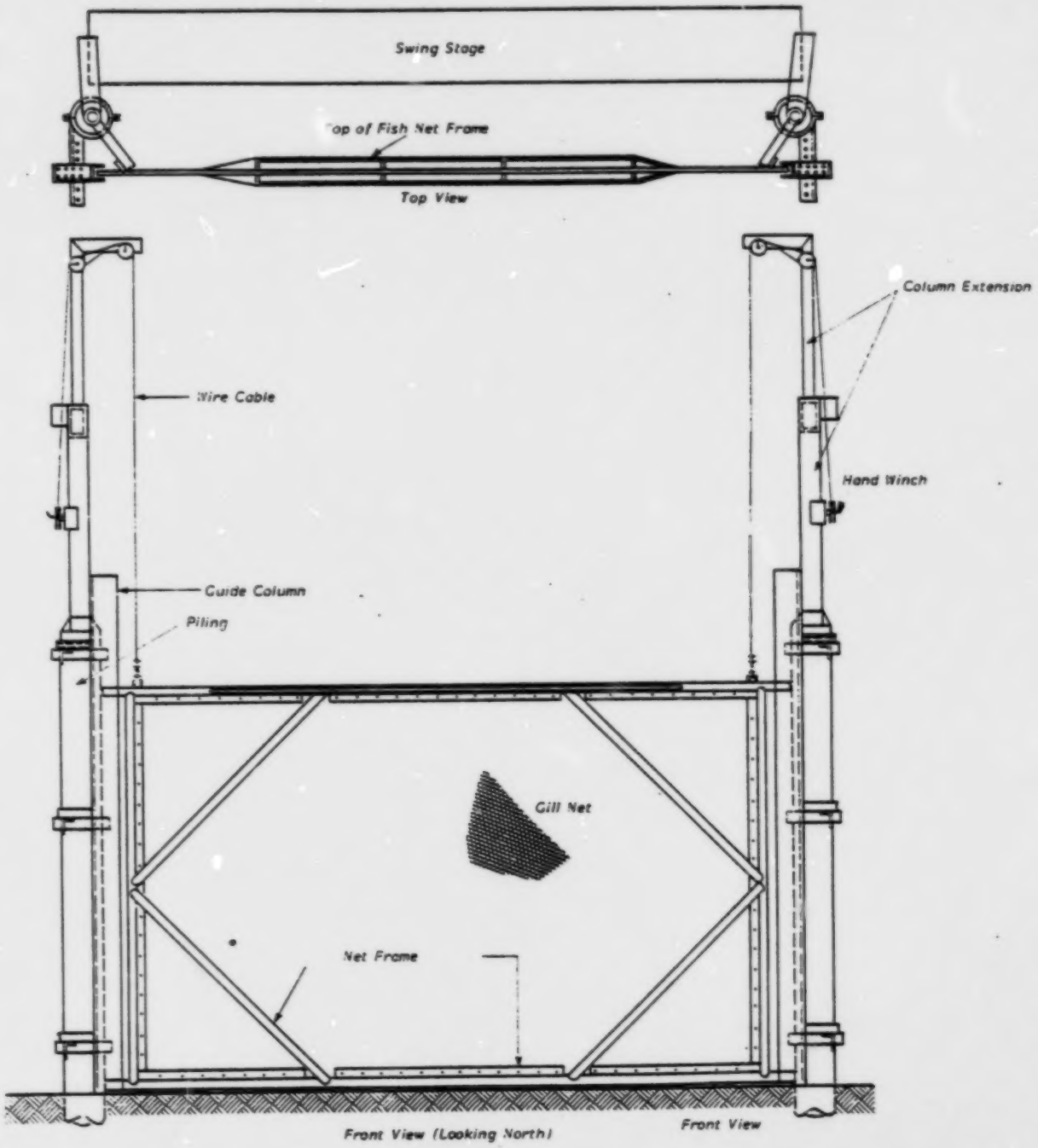

FIGURE 2.1-4
GILL NET FRAME, GUIDES AND SUPPORT
PICKERING DIVERSION STUDY 1982

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(6.7 ft) behind (north of) the rope net barriers. In this position the strobe lights could illuminate (10 lux minimum) the raised rope nets (combined rope net - strobe light test) or could be used as a separate barrier system (strobe light alone) when the rope nets were lowered. Three strobe light models were used in the 1982 diversion study (4 Superfreezeflash II, 14 Pluto Maxistrobes and 10 Superfreezeflash (Lightomation) strobes). The strobe light output was similar for all three models of strobes. These units had previously been used in the 1981 diversion tests (OHRD Report C82 - 19 - K)and were modified to increase operational reliability in the underwater housings. The strobe light flash tubes were scheduled for replacement after 40 operating hours (OHRD Report 82 - 177 - H). Lamp replacement would reduce potential flash tube failure, permitting a potential 10 lux light intensity at the rope net barriers during all strobe tests as recommended following laboratory studies (OHRD Report 81-190-K). Each strobe unit was preset to flash unsynchronized at 200 flashes per minute (fpm).

The unsynchronized strobe light output was measured with an oscilloscope (Phillips Model PM 322) coupled with a diver held photocell on June 3 (OHRD Report 82 - 353 - K). The measurements indicated that the typical strobe lamp sharp rise and decay in light intensity was not being produced by the bank of unsynchronized strobe lights. Instead, the array of strobe lights was producing a continuous light source. It was therefore decided to convert the west structure strobe light units to a synchronized flash system (minutes of June 7, 1982 meeting between Ontario Hydro, OMOE, and OMNR, dated June 25, 1982). The strobe units were synchronized by Electrical Research and reinstalled by July 2 (OHRD Report 82 - 376 - K). Modifications to the strobe units permitted control of the flash rate (0-480 fpm) from a control box located on the west groin.

The fish collecting apparatus consisted of a removable 5.2 m deep by 8.5 m wide (17 x 28 ft) gill net panel (frame net) suspended within an aluminium framework on the north pilings of each structure (Fig. 2.1-4). These nets collected the fish passing through the control and experimental structures (south to north direction) during test replicates. The frame net panels were constructed of 2.5 cm (1.0 in) monofilament or 3.8 cm (1.5 in) nylon mesh during smelt and alewife tests respectively. The frame nets were lowered and raised by paired hand winches at the commencement and conclusion of replicates.

Fish entry into the frame nets from the rear and from the sides of the diversion structures was inhibited by rear and side nets. The 13.3 m (44 ft) collecting nets used to funnel fish to the hoop nets in the 1981 diversion studies were reinstalled to reduce potential frame net gilling of fish entering the structures from the rear (north) (Fig. 2.1-2). They did not serve any fish collection function in the 1982 study. The steel net collars at the cod ends of the collecting nets were sealed off with 3.8 cm (1.5 in) net material. Panels of 5 cm (2 in) net extended along the sides of each structure connecting the

collecting net with the south pilings. Monofilament 2.5 cm (1 in) gill net mesh panels were added to the east and west sides of the east and west test structure June 9 to prohibit alewife entry into the piling area through the sides of the structures.

A 9 m long by 6 m deep (30 x 20 ft), 5 cm (2 in) mesh dividing net was placed south of the diversion structures between the test apparatus to inhibit lateral fish movement across both test structures by the same fish (Fig. 2.1-1).

One 15.2 m (50 ft) panel of experimental nylon gill net (wing net) was set to the open side of each test structure for the duration of individual test replicates (Fig. 2.1-1). Stretched mesh sizes fished for smelt and alewife were 2.5 cm (1.0 in) and 3.8 cm (1.5 in) respectively. The wing nets provided information on fish populations in the vicinity of the diversion structures during test replicates.

Maintenance of all permanent underwater apparatus was contracted to commercial divers. They cleaned the accumulated algal growth and current borne algal strands off of the collecting nets, side panels, and dividing net monthly using a water jet. The top 2 m (6.6 ft) of the rope net barriers required removal of algal accumulations in July and September. Algal growth on the strobe light housing lens caps was hand cleared biweekly during strobe light tests by Biological Research divers.

ii) Fish Occurrence and Behaviour Studies - Acoustic Monitoring

The acoustic fish census equipment (OHRD Report C79 - 87 - K) was modified for use at the pilot diversion site. The acoustic transducer was initially mounted on a portable submerged stand 40 m (131 ft) south of the barrier structures (Fig. 2-1-5). Surface water and lake bed interference with the acoustic signal necessitated movement of the stand to a position 30 m (98 ft) south of the structures after 2 test replicates were completed. Water depth and transducer beam angle restricted monitoring to one half of a structure per test. Lateral movement of the transducer stand unit was required to monitor the other test structure. The monitoring of fish movement at/or past the rope net barrier and south pilings was not possible. Strong echos received from the rope net barrier and pilings were interpreted as bottom by the acoustic system. The acoustic recording equipment was operated from an open boat moored above the transducer stand. Acoustic monitoring could not be conducted during precipitation and high turbulence conditions.

2.2 Experimental Design

i) Diversion System

Fish barrier tests (rope net alone, rope net - unsynchronized strobe lights, unsynchronized strobe lights alone) were scheduled to commence in April. The tests were to consist of 2 sets of 12 short (2 hr) and 4 long (12 hr) replicates with lake populations

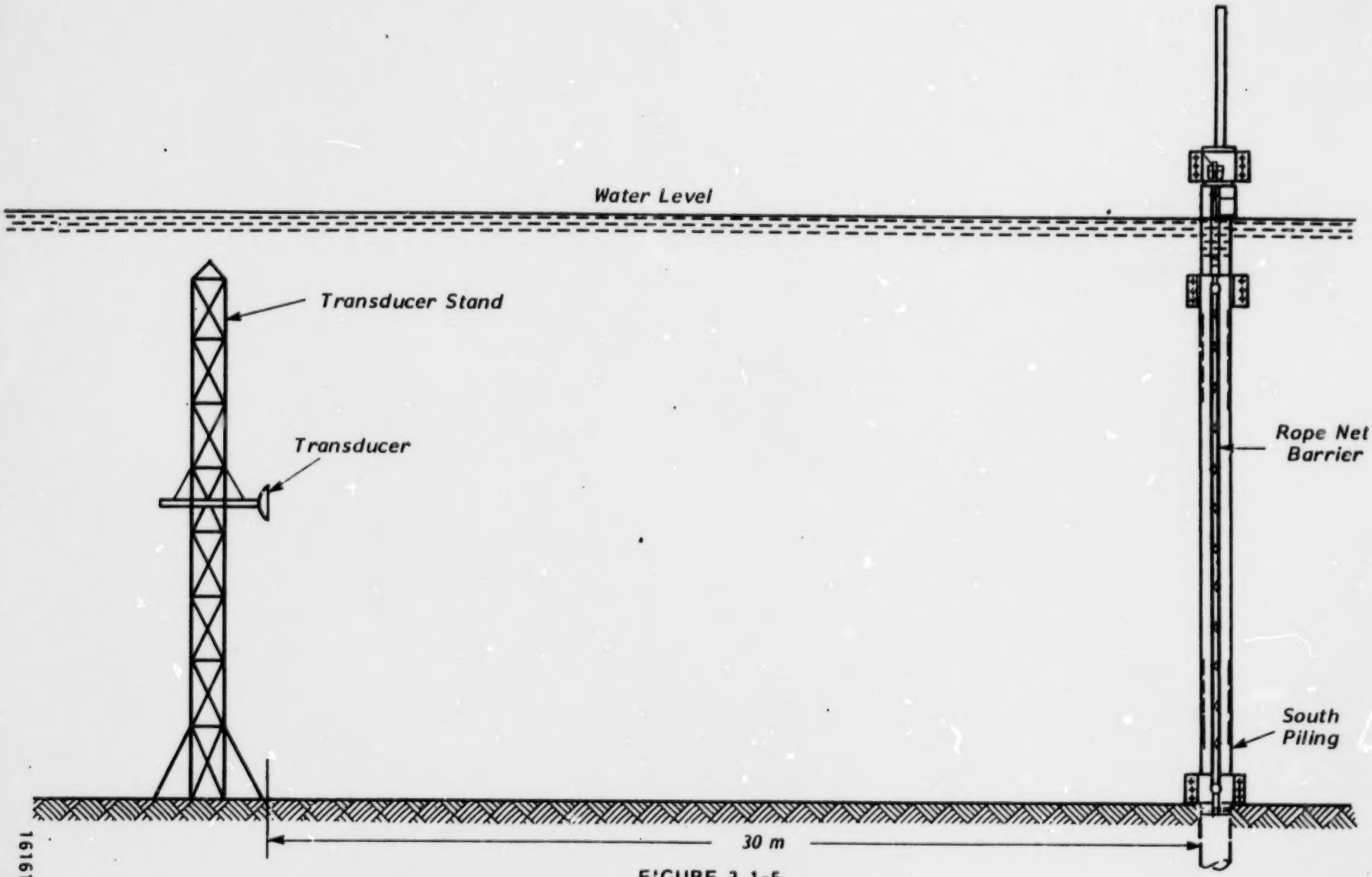

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FIGURE 2.1-5

PICKERING FISH DIVERSION ACOUSTIC SYSTEM LOCATION
PICKERING DIVERSION STUDY, 1982

of rainbow smelt and alewife as the respective test species for each barrier system. The planned schedule was modified following test commencement (Table 2.2-1) due to low frame net fish catches and unsynchronized strobe light problems.

Experimental procedure during smelt and alewife test replicates was identical. Experimentals and controls were conducted simultaneously and location alternated after each series of replicates, weather and equipment permitting. Frame nets were set first followed by the wing nets. Net removal commenced with the wing nets followed by the frame nets. Tests commenced and terminated with the setting and removal of the first frame net. During strobe light experiments the frame nets were set 10 minutes after strobe lamp switch on and were removed prior to strobe lamp switch off.

All fish captured per replicate from the frame and wing net panels were speciated, enumerated and weighed. The direction in which the fish entered the nets (lake or shore) was recorded after May 7. The analysis of barrier effectiveness was based upon fish entering the nets from the lake (south). No information is available on the number of fish that may have entered the structures from the lake and then returned to the lake without being caught in the frame nets. Data are also not available on the number of fish contained within the piling area at test commencement which may have been possibly caught in the frame nets. It is probable that the noise created during the setting of the frame nets would have dispersed fish from the piling area.

Water temperature and turbidity samples were obtained at the surface, 2.5 m and 5.0 m depths in front of each test structure at test commencement. Secchi disc measurements were recorded during day rope net alone replicates. Light meter readings (Lambda Model 11-185 Photometer/Quantum meter) were attempted by SCUBA divers adjacent to the rope net during night strobe light tests. Light meter cable movement caused by boat or SCUBA diver movement and/or underwater current resulted in erratic light meter needle deflection. No accurate light meter readings could thus be recorded. Light meter readings were not attempted after July 5.

Wind direction and velocity, lake surface condition, cloud cover and precipitation data were recorded for each replicate. Current direction and velocity at the diversion structures was not monitored.

The actual replicate frame and wing net smelt and alewife catches (lake or shore) were converted to 2 hour catch per unit effort (CUE) values for data analysis. Linear regression analysis was used to test the accuracy of the conversion from actual fish catches to 2 hour CUE values. No significant difference ($r = 0.9226$) was indicated in the fish catch data transformation. The non-parametric two-tailed Wilcoxon matched pairs signed ranks test was used to test for significant differences between barrier

Table 2.2-1

Pickering Diversion Replicate Schedule
Pickering Diversion Study, 1982

Test Species	Date	Diversion System	Number of Replicates			Duration
			Day	Night	Combined*	(Hrs)
Smelt	April 26-May 20	rope net alone	23	31	5	2-23
	May 17-May 21	rope net-unsynchronized strobe	1	3	1	2-12.5
Alewife	June 7- July 30	rope net alone	41	36	5	2-22.5
	May 25-June 4	rope net-unsynchronized strobe	2	12	0	2
	July 5-July 30	rope net-synchronized strobe	0	20	1	2-13

* - day, night and replicates > 12 hr duration

system (rope net alone, rope net -unsynchronized strobe lights and rope net - synchronized strobe lights) experimental and control frame net CUE values and wing net CUE values during daylight (0800-2000 hr), night (2000-0800 hr) and combined (daylight and dark) conditions. Replicates which exceeded 12 hours duration were not used in the day or night CUE data analysis since day and night light conditions were included in the duration of the replicates. However all replicates were used in the analysis of the combined day and night CUE data. Only replicates in which 5 or more fish (lake) were collected in the frame and wing nets were included in the statistical analysis. East and west structure water temperature and turbidity values were compared with one way analysis of variance. Two way analysis of variance was used to test for significant variation in the rope net barrier frame net alewife CUE values during periods of surface water turbulence and during changing surface illumination. The 99 percent significance level (0.01) was used in determining significance in all statistical tests.

a) Smelt Tests

Rainbow smelt were used as the test species in barrier experiments from April 26 - May 21 (Table 2.2-1). The rope net alone was tested April 26 - May 20. Rope net - unsynchronized strobe light tests were performed May 17 - 21 near the end of the smelt run. Low frame net catches (CUE=0) did not justify the use of the strobe lights earlier in the smelt test period. Initial daylight (0800-2000 hr) and night (2000-0800 hr) tests were of 2 hours duration. Longer term tests (4-10 hr) were conducted between crew shifts. On May 5, test duration was altered to a maximum duration (weather permitting) of 12 hours in an effort to increase the frame net catches.

All barrier tests with smelt were performed with 2.5 cm (1.0 in) monofilament gill net mesh in the frame nets and 2.5 cm nylon experimental gill net mesh in the wing net sets. The 2.5 cm mesh was size selective for smelt. Incidental catches of other fish species were recorded but not used in data analysis.

b) Alewife Tests

Test replicates with alewife as the target species commenced May 25 and extended until July 30 (Table 2.2-1). The rope net - unsynchronized strobe light barrier test combination was tested May 25 - June 4. Rope net - synchronized strobe light barrier tests were conducted at night July 5 - 30. Rope net alone tests were performed during the day and night June 7 - July 2 and during the day July 5 - 30. Test duration varied from 2 - 13 hours in the strobe light studies and from 2 - 12 hours during rope net alone tests. The synchronized strobe lamp flash rate was altered during replicates within a 60-455 fpm range to determine the most effective flash rate for alewife avoidance. Nylon 3.8 cm (1.5 in) gill net mesh was fished in the frame and wing net sets in all alewife experiments. The 3.8 cm mesh was size selective for alewife. Incidental catches of other fish

species were recorded but not used in data analysis.

ii) Fish Occurrence and Behaviour Studies

Monitoring of fish behaviour and occurrence with the acoustic fish census equipment was performed coincident with barrier diversion tests as outlined in Table 2.2-2. The acoustic system was prewarmed and checked one half hour prior to test commencement. The 2 hour monitoring studies commenced with the start of a test replicate. The acoustic equipment was set for 120 transmissions in a 30 second interval with a chart speed of 0.18 cm/sec. Depth monitoring ranges were set at 7, 14, 21, 28,and 35 m on June 9 and 11 and at 5, 10, 15, 20, 25 and 30 m June 14-July 30 (Table 2.2-1). Wind direction and velocity, lake surface condition and cloud cover were estimated for each monitoring run. Throughout the synchronized strobe tests the acoustic census equipment was used to monitor fish occurrence and behaviour at the varied strobe lamp flash rates in an effort to determine the most effective flash rate for diverting alewife.

The analogue echograms were qualitatively assessed every tenth interval for apparent fish densities, fish trajectory in relation to the structures and fish velocity. Fish densities were not corrected for variation in transducer beam volume. No differentiation was possible with the acoustic monitoring equipment between either vertical or lateral fish movement (parallel) or stationary fish. The rope net alone test and control data were subsequently analyzed quantitatively at the request of ES&A. The data were corrected for variation in sample volume due to beam angle when quantitatively analysed. The June 9 and 11 fish density data were altered to correspond with the 0-30 monitoring range used in all subsequent studies.

Proposed studies with underwater video equipment were not feasible. Underwater light and turbidity levels reduced the effective camera field of view.

3.0) Results

One hundred and eighty-one replicates, 2 to 23 hours duration, were performed throughout the study period (Table 2.2-1). The fish catch data are presented as 2 hour CUE values in Appendix B and summarized in Tables 3.0-1,2,3. Water temperature, turbidity and Secchi disc measurements are reported in Appendix C and are summarized in Table 3.0-4. Analysis of the water temperature and turbidity values and Secchi disc measurements indicated no significant difference between east and west structure parameters during smelt and alewife replicates respectively (one way analysis of variance, Tables 3.0-5,6)

3.1) Smelt Tests

i) Rope net barrier alone

Fifty-nine (23 daylight, 31 night and 5 > 12 hr duration) rope

TABLE 2.2-2

ACOUSTIC MONITORING PROGRAM TEST SUMMARY
PICKERING DIVERSION STUDY, 1982

Date	Structure Monitored	Test Configuration	Time	Strobe Flash Rate (fpm)
June 9	West	Rope Net	Night	
June 11	West	Control	Day	
June 14	East	Control	Day	
June 14	East	Control	Night	
June 16	East	Rope Net	Day	
June 16	East	Rope Net	Night	
June 17	East	Rope Net	Day	
June 30+	West	Strobes*	Night	105-240
July 5	West	Strobes*	Night	180
July 13	West	Rope Net	Night	
July 16	West	Strobes*	Night	180-240
July 19+	West	Strobes*	Night	112-176
July 20	West	Strobes*	Night	60-148
July 21	West	Strobes*	Night	48-68
July 22	West	Strobes*	Night	96-240
July 23	West	Strobes*	Night	100
July 26	West	Strobes*	Night	180-220
July 27	West	Strobes*	Night	220
July 28	West	Strobes*	Night	180-455
July 29	West	Strobes*	Night	180-455
July 30	West	Strobes*	Night	215-455

fpm - flashes per minute
+ - test run
* - synchronized strobes

TABLE 3.0-1

AVERAGE CATCHES PER UNIT EFFORT (2 HR)
IN CONTROL AND EXPERIMENTAL FRAME NETS
PICKERING DIVERSION STUDY,1982

		Fish CUE (Frame Net)														
		Day					Night					Combined				
		Experimental			Control		Experimental			Control		Experimental			Control	
Fish Species	Diversion System	Number of Trials	Range	Mean	Range	Mean	Number of Trials	Range	Mean	Range	Mean	Number of Trials	Range	Mean	Range	Mean
Smelt	RN	23	0	0	0-1	0	31	0-1	0	0-1	0	59	0-1	0	0-1	0
	RNUS	1	0	0	0	0	3	1-5	2.7	0	0	5	0-5	1.8	0	0
Alewife	RN	41	0-45	2.6	0-75	7.0	36	0-12	1.8	0-89	15.9	82	0-45	2.3	0-89	10.9
	RNUS	2	0	0	0-1	0.5	12	29-231	110.6	9-123	38.7	14	29-231	94.8	9-123	33.2
	RNSS	0	-	-	-	-	20	1-85	28.0	0-89	30.7	21	1-85	26.8	0-89	29.4

RN - rope net
RNUS - rope net - unsynchronized strobe
RNSS - rope net - synchronized strobe

Table 3.0-2

TOTAL MEAN SMELT (LAKE FISH) CATCH PER UNIT EFFORT
PICKERING DIVERSIOIN STUDY, 1982

		EAST		WEST			WEST		EAST	
	NUMBER OF REPLICATES	EXPERIMENTAL FRAME CUE	EXPERIMENTAL WING CUE	CONTROL FRAME CUE	CONTROL WING CUE	NUMBER OF REPLICATES	EXPERIMENTAL FRAME CUE	EXPERIMENTAL WING CUE	CONTROL FRAME CUE	CONTROL WING CUE
RN DAY	6	0	5	0	7	17	0	18	0	9
RN NIGHT	8	1	320	0	412	23	1	997	1	881
RN COMBINED	16	1	331	1	499	43	1	1100	2	940
RNUS DAY	0	0	0	0	0	1	0	0	0	1
RNUS NIGHT	1	1	5	0	3	2	7	64	0	9
RNUS COMBINED	2	2	10	0	3	3	7	64	0	10

RN - rope net alone
RNUS - rope net and unsynchronized strobe lights

Table 3.0-3

TOTAL MEAN ALEWIFE (LAKE FISH) CATCH PER UNIT EFFORT
PICKERING DIVERSION STUDY, 1982

		EAST		WEST			EAST		WEST	
	NUMBER OF REPLICATES	EXPERIMENTAL FRAME CUE	EXPERIMENTAL WING CUE	CONTROL FRAME CUE	CONTROL WING CUE	NUMBER OF REPLICATES	EXPERIMENTAL FRAME CUE	EXPERIMENTAL WING CUE	CONTROL FRAME CUE	CONTROL WING CUE
RN DAY	15	15	179	147	244	26	90	635	141	805
RN NIGHT	17	12	523	338	510	19	52	352	235	405
RN COMBINED	36	29	750	491	772	46	159	992	403	1255
RNUS DAY	2	0	9	1	12	0	-	-	-	-
RNUS NIGHT	7	700	926	343	509	5	627	423	121	281
RNUS COMBINED	9	700	935	344	521	5	627	423	121	281
RNSS DAY	0	-	-	-	-	0	-	-	-	-
RNSS NIGHT	0	-	-	-	-	20	559	667	613	901
RNSS	0	-	-	-	-	21	562	669	617	903

RN - rope net alone
RNUS - rope net and unsynchronized strobe lights
RNSS - rope net and synchronized strobe lights

TABLE 3.0-4

Range of Experimental and Control Water Temperature, Turbidity and Secchi Disc Measurements Pickering Diversion Study, 1982

	Smelt		Alewife	
	Surface	Bottom	Surface	Bottom
Water Temperature ('C)	7.0 - 16.5	5.0 - 10.3	8.0 - 21	5.0 - 17
Turbidity (NTU)	0.8 - 20	0.9 - 21	0.8 - 3.4	0.8 - 4.8
Secchi Disc (m)	1.2 - 3.3	-	1.5 - 3.5	-

Table 3.0-5

EAST AND WEST STRUCTURE TEMPERATURE (°C)
ANOVA RESULTS
PICKERING DIVERSION STUDY,1992

SMELT

SAMPLE DEPTH	SURFACE				MIDDLE				BOTTOM			
	MEAN		DEGREE OF FREEDOM	F VALUE	MEAN		DEGREE OF FREEDOM	F VALUE	MEAN		DEGREE OF FREEDOM	F VALUE
	EAST	WEST			EAST	WEST			EAST	WEST		
RN	9.9	10.1	1,106	1.98	7.0	7.2	1,106	0.64	6.5	6.5	1,106	0.18
US	10.2	10.3	1,6	0.02	9.3	9.1	1,6	0.03	8.3	8.1	1,6	0.03

ALEWIFE

RN	13.9	14.5	1,146	1.95	11.5	11.4	1,146	0.07	10.5	10.3	1,146	0.17
US	14.0	14.7	1,26	0.67	11.0	10.8	1,26	0.07	10.2	10.2	1,26	0.01
SS	15.0	15.8	1,35	0.54	13.6	13.9	1,35	0.09	12.8	13.0	1,35	0.04

RN - rope net alone

US - unsynchronized strobes and rope net

SS - synchronized strobes and rope net

Table 3.0-6

EAST AND WEST STRUCTURE TURBIDITY (NTU)
ANOVA RESULTS
PICKERING DIVERSION STUDY, 1982

SMELT

SAMPLE DEPTH	SURFACE				MIDDLE				BOTTOM			
	MEAN EAST	MEAN WEST	DEGREE OF FREEDOM	F VALUE	MEAN EAST	MEAN WEST	DEGREE OF FREEDOM	F VALUE	MEAN EAST	MEAN WEST	DEGREE OF FREEDOM	F VALUE
RN	2.6	2.5	1,106	0.08	2.8	2.4	1,104	0.49	3.0	2.5	1,100	0.53
US	1.6	1.3	1,4	0.42	1.9	1.8	1,6	0.09	1.8	1.8	1,6	0.0
ALEWIFE												
RN	1.6	1.6	1,148	0.93	1.8	1.7	1,148	0.67	1.8	1.8	1,145	0.03
US	1.5	1.6	1,26	0.12	1.6	1.7	1,26	0.26	1.6	1.9	1,26	2.72
SS	1.7	1.6	1,36	0.52	1.9	1.7	1,36	0.50	1.8	2.0	1,36	1.25

RN - rope net alone
US - unsynchronized strobes and rope net
SS - synchronized strobes and rope net

net barrier alone tests were performed with smelt as the target species (Tables 3.0-1,2). The total frame and wing net smelt (lake) catches were 8 and 7107 fish respectively. Smelt were collected in either the experimental or control frame nets during 3 of the 59 test replicates. On the 3 occasions (1 night, 2 > 12 hr duration) when smelt were collected, the mean frame net experimental and control CUE values were 0.3 and 0.7 respectively. No significant differences could be determined between experimental and control frame net CUE values during day, night, and combined day and night replicates (Table 3.1-1). The day and night wing net CUE values ranged from 0-5 and 0-235 smelt respectively. The night wing net CUE values (>5 fish, $n=28, \bar{x}=49.6$) were significantly greater than the night frame net CUE values ($n=28, \bar{x}=0$). The experimental and control day , night and combined day and night wing net CUE values were not significantly different (Table 3.1-2). Alewife (n=5) was the only incidental fish species collected in the frame nets during the smelt studies. Alewife (n=18), mottled sculpin (n=2) and spottail shiner (n=3) were collected in the wing nets.

ii) Rope net-unsynchronized strobe lights

Five rope net-unsynchronized strobe light (1 day, 3 night, 1 > 12 hr duration) replicates were conducted May 17-21 (Tables 3.0-1,2). Thirty-three smelt were collected in the frame nets (33 experimental, 0 control) while 753 smelt were captured in the wing nets (551 experimental, 202 control). The mean daylight frame and wing net CUE values were 0 and 0.5 respectively. At night the experimental frame net CUE values ranged from 1-5 and were not significantly greater than the control frame net CUE values (CUE=0, Table 3.1-1). The night experimental and control wing net CUE values ranged from 2-62 and 0-9 respectively. More smelt were consistently collected in the experimental wing nets ($n=3, \bar{x}23.0$) than in the control wing nets ($n=3, \bar{x}=4.0$) however, the variation between the experimental ($n=2, \bar{x}=33.5$) and control ($n= 2, \bar{x}=6.0$) wing net CUE values was not significant (Table 3.1-2). No incidental fish species were collected during these studies.

The number of functioning strobe units (200 fpm) is reported in Appendices D and E. The east structure strobe lights (n=12) functioned without any strobe unit failures occurring during test replicates (2). Experimental replicates at the west structure were conducted with only 4 (May 17,n=1) and 7 (May 21,n=2) operational strobe units. Circuit breaker and strobe bulb failures were responsible for the inoperable strobe units. No accurate light intensity measurements are available to determine the light intensity at the rope net during the replicates. It is also not known whether a continuous light source or the required strobe light flash was produced in the replicates with < 12 operational strobes.

TABLE 3.1-1

EXPERIMENTAL VS CONTROL FRAME NET CATCH PER UNIT EFFORT (2HR) ANALYSIS*
PICKERING DIVERSION STUDY, 1992

SMELT

	DAY				NIGHT				COMBINED			
REPLICATE	# of TRIALS	EXPT MEAN	CONTROL MEAN	S	# of TRIALS	EXPT MEAN	CONTROL MEAN	S	# of TRIALS	EXPT MEAN	CONTROL MEAN	S
Rope net	0	-	-	-	0	-	-	-	0	-	-	-
Rope net Unsynchronized Strobes	0	-	-	-	1	5	0	NS**	1	5	0	NS

ALEWIFE

Rope net	10	9.6	26.6	NS	18	3.2	30.9	<0.01	29	5.8	29.4	<0.01
Rope net Unsynchronized Strobes	0	-	-	-	12	110.6	38.7	<0.01	-	-	-	-
Rope net Synchronized Strobes	-	-	-	-	18	30.9	34.0	NS	19	29.5	32.4	NS

* - Two-tailed Wilcoxon Matched Pairs Signed-Ranks Test
($\bar{x}$ 5 fish per 2 hour period)

S - Significance

NS - Not Significant

** - smelt were attracted to the strobe light piling area

TABLE 3.1-2

EXPERIMENTAL VS CONTROL WING NET CATCH PER UNIT EFFORT (2HR) ANALYSIS♦
PICKERING DIVERSION STUDY, 1982

SMELT

REPLICATE	DAY				NIGHT				COMBINED			
	# of TRIALS	EXPT MEAN	CONTROL MEAN	S	# of TRIALS	EXPT MEAN	CONTROL MEAN	S	# of TRIALS	EXPT MEAN	CONTROL MEAN	S
Rope net	1	5	1	NS	28	52.8	46.3	NS	29	44.7	51.1	NS
Rope net Unsynchronized Strobes	-	-	-	-	2	33.5	6.0	NS	-	-	-	-

ALEWIFE

Rope net	32	27.2	31.7	NS	29	25.7	31.3	NS	63	26.4	31.4	NS
Rope net Unsynchronized Strobes	-	-	-	-	12	112.4	65.8	NS	-	-	-	-
Rope net Synchronized	-	-	-	-	20	33.4	45.1	NS	20	33.4	45.1	NS

♦ - Two-tailed Wilcoxon Matched Pairs Signed-Ranks Test
($\geq$ 5 fish per 2 hour period)

S - Significance

NS - Not Significant

3.2 Alewife Tests

1) Rope net alone

Eighty-two rope net alone (41 daylight, 36 night and 5 > 12 hr duration) test replicates were performed May 25-July 30 with alewife as the test species (Tables 3.0-1,3). The total lake frame and wing net alewife catches were 2754 and 9080 respectively. The daylight test duration ranged from 2 - 11.4 hours while night replicate duration ranged from 2 - 22.3 hours. Five night replicates exceeded 12 hours duration and are not included in the night data analysis. The daylight experimental and control frame net CUE values (n=41) ranged from 0-45 ($\bar{x}$=2.6) and 0-75 ($\bar{x}$=7.0) respectively, indicating a reduction of 63% in alewife passage between experimental and control structures. However, the difference between experimental (n=10,$\bar{x}$=9.6) and control (n=10,$\bar{x}$=26.6) frame net catches was not significant (Table 3.1-1). The daylight experimental and control wing net CUE values (lake fish) ranged from 1-94 and 1-143 with mean CUE values of 19.9 and 25.6 respectively. The difference between the experimental (n= 32,$\bar{x}$=27.2) and control (n=32,$\bar{x}$=31.7) daylight wing net CUE values was not significant (Table 3.1-2). Statistical analysis also indicated no significant variation between east and west structure wing net CUE values regardless of which side was designated as the experimental.

The rope net alone night experimental and control frame net CUE values (n=36) ranged from 0-12 ($\bar{x}$=1.8) and 0-89 ($\bar{x}$=15.9) respectively, indicating a reduction of 89% in alewife passage between experimental and control structures. Analysis of the frame net CUE data indicated a significant reduction in the experimental alewife CUE values (n=18,$\bar{x}$=3.2) compared to the control CUE values (n=18,$\bar{x}$=30.9, Table 3.1-1). The experimental and control night wing net CUE values (lake fish) ranged from 1-87 ($\bar{x}$=19.9) and 1-93 ($\bar{x}$=24.5) respectively. The difference between experimental (n=29,$\bar{x}$=25.7) and control (n=29,$\bar{x}$=31.3) wing net CUE values was not significant (Table 3.1-2). The east and west structure CUE values were not significantly different regardless of which side was designated as the experimental. Smelt (n=3) was the only incidental fish species collected in the frame nets during these studies. Smelt (n=34), white sucker (n=1) and yellow perch (n=2) were collected in the wing nets.

The day and night experimental and control CUE data were combined for experimental and control situations. The combined experimental and control mean frame net CUE values (n=82) were 2.3 and 10.9 respectively indicating a 79% reduction in alewife passage between experimental and control structures. The difference between the experimental (n= 29,$\bar{x}$=5.8) and control (n=29,$\bar{x}$=29.4) CUE data was significant (Table 3.1-1). The combined day and night experimental and control mean wing net CUE values (n=82) were 21.2 and 24.7 respectively. Analysis of the wing net CUE values indicated no significant variation between experimental (n=63,$\bar{x}$=26.4) and control (n=63,$\bar{x}$=31.4) replicates (Table 3.1-2).

The rope net appeared to be most effective at night (89% reduction). The illumination of the rope net barrier by the moon on clear nights was hypothesized as a possible reason for the differences between experimental and control frame net catch results. Two way analysis of variance indicated the significant differences between experimental and control frame net CUE values ($F_{3,24}=8.2$) were not attributable to cloud cover ($F_{8,24}=1.07$).

Surface turbulence conditions were also analyzed to determine if they contributed to the difference in experimental and control frame net catches. Two way analysis of variance indicated the significant differences between experimental and control frame net CUE values ($F_{3,48}=9.7$) were not attributable to surface turbulence conditions ($F_{16,48}=0.8$).

Eight acoustic monitoring studies (4 day, 4 night) were performed during the alewife rope net alone tests (Table 2.2-2,3.2-1,2, Appendix F). The data were quantitatively analyzed and the fish density data were transformed to correct for transducer beam volume. The experimental and control replicates were each monitored twice during the day studies. The average number of echoes/transmission for the day experimentals and controls were highly variable ranging from 1-28 and 3-78 echoes respectively. During the experimental situations the majority of all echoes received (56% combined data) were within 0-5 m of the rope net however the average number of echoes/transmission was low (15,Table 3.2-1). Monitoring of the control structure indicated 14% of all echoes received were recorded within the 0-5m range while 60% of all echoes received were recorded within the 15-30m range. The average number of echoes/transmission (41) was higher during the control situation than in the experimental situation. Qualitative analysis of the fish trajectory data indicated the majority of fish within the 0-5m range of the structures remained stationary or moved parallel to the entrance into the experimental (43% of all echoes) and control (97% of all echoes) structures (Table 3.2-2). No fish trajectory could be discerned for 43% of the echoes received within the 0-5m range of the experimental structures. The actual experimental (CUE=0) and control (CUE=1) frame net catches on the dates of the daylight monitoring studies were very similar.

The experimental and control structures were monitored on 3 and 1 occasions respectively during the night rope net alone monitoring studies. The average number of echoes/transmission at the experimental barrier ranged from 4-212 echoes ($\bar{X}=75$,Table 3.2-1). The average number of echoes/transmission for the single control was 5. The majority of echoes received during the night experimental studies were within 15-30 m (52% of all echoes received) and 10-15 m (34% of all echoes received) of the barrier. In contrast the majority of echoes in the control replicate were located within the 0-5 m (63% of all echoes received) and 5-10 m (33% of all echoes received) ranges. Qualitative analysis of the experimental replicate fish trajectory data indicated that within 0-5 m of the rope net

TABLE 3.2-1

DISTRIBUTION OF FISH (% OF ECHOES) RELATIVE TO DISTANCE FROM THE BARRIER
PICKERING DIVERSION STUDY, 1982

Date	Structure Monitored	Test Configuration	Distance From Barrier (m) 0-5	5-10	10-15	15-30	Average Number of Echoes/Transmission
			DAY				
June 16	East	Rope Net	99	0	1	0	1
June 17	East	Rope Net	55	29	15	1	28
June 14	East	Control	80	17	1	2	3
June 11	East	Control	12	13	13	63	78
			NIGHT				
June 9	West	Rope Net	2	9	35	54	212
July 13	West	Rope Net	41	46	12	2	4
June 16	East	Rope Net	48	15	16	21	8
June 14	East	Control	63	33	0	4	5
			DAY				
		Combined Rope Net	56	28	15	1	15
		Combined Control	14	13	12	60	41
			NIGHT				
		Combined Rope Net	4	10	34	52	75
		Control	63	33	0	4	5

TABLE 3.2-2

SUMMARY OF OBSERVED FISH TRAJECTORY RELATIVE TO THE DIVERSION STRUCTURE FROM ACOUSTIC MONITORING PICKERING DIVERSION STUDY, 1982

Trajectory Description	Distance From Barrier (M) 0-5	5-10	10-15	15-30
Combined Day Experimentals				
Away from barrier	0+	3	0	3
Erratic:towards/away	3	0	0	0
Parallel/Stationary*	43	34	26	3
Shallow slope towards	11	0	3	0
Highly sloped towards	0	0	0	0
Very highly sloped towards	0	0	0	0
No trajectory observed	43	63	71	94
Combined Day Controls				
Away from structure	0	0	0	0
Erratic:towards/away	0	0	8	5
Parallel/Stationary	97	97	35	32
Shallow slope towards	0	0	0	0
Highly sloped towards	0	0	0	0
Very highly sloped towards	0	0	0	0
No trajectory observed	3	3	57	62
Combined Night Experimentals				
Away from barrier	0	0	0	0
Erratic:towards/away	0	0	0	0
Parallel/Stationary	47	34	10	24
Shallow slope towards	53	51	46	22
Highly sloped towards	0	0	0	0
Very highly sloped towards	0	0	0	0
No trajectory observed	0	15	44	54
Night Control				
Away from structure	0	0	0	0
Erratic:towards/away	0	0	0	0
Parallel/Stationary	95	100	5	0
Shallow slope towards	5	0	0	0
Highly sloped towards	0	0	0	0
Very highly sloped towards	0	0	0	0
No trajectory observed	0	0	95	100

\+ - percentage of echoes in that depth range with the indicated trajectory

* - fish may move parallel to barrier or remain stationary in front of structure

shallow echo slopes towards the barrier (53% of all echoes) and stationary or parallel movement along the barrier (47% of all echoes) predominated (Table 3.2-2). Fish velocity towards the rope net in these situations was <0.1 m/sec. During the control replicate fish trajectory within the 0-5 m range was primarily stationary or parallel (95% of all echoes) to the control structure entrance. Fish velocity towards the control structure could not be determined for 95% of all echoes received. The differences between experimental and control results may be attributed to natural alewife movement in an open lake situation.

The mean experimental and control night frame net CUE values during acoustic monitoring studies were 0.7 and 8 respectively. A low experimental frame net CUE value of 0 was recorded on June 9, the date of highest monitored alewife concentration (212 echoes/transmission,Table 3.2-1). On this date the monitored alewife schools generally maintained a distance of >10 m from the rope net (Table 3.2-1) and displayed no distinct avoidance behaviour (Table 3.2-2).

ii) Rope net - unsynchronized strobe lights

Fourteen rope net - unsynchronized strobe light barrier replicates (2 day, 12 night) were conducted May 25-June 4 (Tables 3.0-1,3). A total of 1792 alewife were collected in the frame nets (1327 experimental, 465 control) while 2013 alewife were collected in the wing nets (1226 experimental, 787 control). The mean day experimental and control frame net CUE values were 0 and 0.5 respectively. The mean day experimental and control wing net CUE values were 4.5 and 6.0 respectively. Statistical analysis of the day frame and wing net data was not performed due to the small sample size(n=2).

The night rope net - unsynchronized strobe light experimental and control frame net CUE values (n=12) ranged from 29 - 231 and 9 - 123 respectively indicating an attraction of alewife to the vicinity of the experimental structure. The difference between the experimental (n= 12,$\bar{x}$=110.6) and control (n=12,$\bar{x}$=38.7) frame net CUE values was significant (Table 3.1-1). Analysis of the night experimental (n=12,$\bar{x}$=112.4) and control (n=12,$\bar{x}$=65.8) wing net CUE data (lake fish) indicated significantly higher CUE values in the experimental wing nets than in the control wing nets (Table 3.1-2). The replicates were conducted with maxima of 12 (east) and 10 (west) functioning strobe units (Appendices D,E). The minimum number of operational strobes at each structure was 6. Only 4 replicates were conducted with the minimum number of operational strobes. Alewife may have responded differently during replicates with 12 operating strobes and <12 operating strobes. However, data are not available to indicate any change in alewife behaviour. Light intensity measurements are not available to determine the light intensity at the rope net during any of the strobe light replicates. Smelt (n=6) and white sucker (n=1) were the only incidental fish species collected in the frame nets. Round whitefish (n=1), smelt (n=8) and white sucker (n=2) were collected in the wing nets.

Rope net - unsynchronized strobe light alewife replicates were discontinued following oscilloscope studies of the strobe unit flash output on June 3. The studies indicated a nearly continuous light output rather than the required rapid light rise and decay typical of a single strobe light (OHRD Report 82-353-K).

iii) Rope net = synchronized strobe lights

Twenty - one rope net - synchronized strobe light replicates (20 night, 1 > 12 hr duration) were conducted July 5 - 30 with alewife as the test species (Tables 3.0-1,3). The duration of the replicates varied from 3.5-13 hours ($\bar{x}$=7.6 hr). One test replicate exceeded the 12 hour duration limit and is not included in the night data analysis. The actual fish catches during the test replicates were 3396 alewife in the frame nets (1480 experimental, 1916 control) and 4354 alewife in the wing nets (1837 experimental, 2517 control). The experimental and control frame net CUE values ranged from 1-85 ($\bar{x}$=28.0) and 0-89 ($\bar{x}$=30.7) respectively. The differences between the experimental (n=18,$\bar{x}$=30.9) and control (n=18,$\bar{x}$=34.0) frame net CUE values were not significant (Table 3.1-1). The experimental and control wing net CUE values (lake fish) ranged from 3-161 ($\bar{x}$=33.4) and 3-153 ($\bar{x}$=45.1) respectively. The difference between the experimental (n=20,$\bar{x}$=33.4) and control (n=20,$\bar{x}$=45.1) wing net CUE values was not significant (Table 3.1-2). No incidental fish species were collected during these studies.

The CUE results of the 20 night and 1 > 12 hr duration replicates were combined. The experimental and control mean frame net CUE values were 26.8 and 29.4 respectively. The difference between the experimental (n=19, $\bar{x}$=29.5) and control (n=19,$\bar{x}$=32.4) CUE data was not significant (Table 3.1-1). The combined experimental and control mean wing net CUE values were 31.9 and 43.0 respectively. Analysis of the wing net CUE values indicated no significant variation between experimental (n=20,$\bar{x}$=33.4) and control (n=20,$\bar{x}$=45.1) replicates (Table 3.1-2).

The number of operating strobes varied from 6 (July 29) to 10 (July 8-22,23,26, Appendices D,E). The malfunctioning light meter prohibited the recording of light intensities at the barrier. However, the strobe light system was designed to provide effective coverage of the rope net when only 10 strobe light units were operating.

Fish densities and movement within 30 m of the rope net - synchronized strobe barrier were monitored with the acoustic monitoring system on 13 occasions (11 experimental replicates, 2 equipment tests, Table 2.2-2). Qualitative analysis of the acoustic data indicated that within 5 m of the barrier system fish densities were extremely variable with approximately equal occurrence of high fish densities (29% of intervals analyzed) and none or few fish (23% of intervals analyzed) (Appendix F). Five to 10 m from the experimental structure low fish densities (31%

of intervals analyzed) and none or few fish (26% of intervals analyzed) predominated. Moderate and high fish densities were determined in 18% of the intervals analyzed 5 to 10m from the barrier. None or few fish was the predominant fish density determined 10-15m (55% of intervals analyzed) and 15-30m (82% of intervals analyzed) from the barrier system.

Analysis of the fish trajectory data indicated fish primarily remained stationary or moved parallel to the diversion system entrance (Table 3.2-3). Fish trajectories 0-5 and 5-10m from the experimental system were primarily stationary or parallel (38,29% of all echoes received) or shallow sloped towards (22,29% of all echoes received) the barrier. Fish trajectories were not discernible for 50 and 79% of all the echoes in the 10-15 and 15-30 m ranges respectively; however, a shallow slope towards the barrier was exhibited by 28% (10-15m) and 17% (15-30m) of all recorded echoes.

The observed fish velocities towards the barrier system ranged from .02 - .12 m/sec (Appendix F). Most fish velocities occurred within the 0.04-.06 m/sec. range (21% of all echoes).

Comparison of the experimental frame net CUE values with the corresponding acoustic fish density data indicated no consistent patterns or trends. A very low CUE value (CUE=1) was recorded July 28 during an indicated period of high (46% of all echoes received) fish density. The west July 28 wing net CUE value (lake,CUE=17) indicated alewife densities within the vicinity of the experimental structure were low. The maximum CUE value recorded during a monitoring study (July 22) was 154. This value was recorded during an indicated fish density of primarily none or few fish (61% of intervals analyzed) within 0-5 m of the barrier. However, the July 22 experimental wing net CUE value (lake,CUE=19) indicated low alewife densities within the vicinity of the experimental structure.

4.0 Discussion

The fish barrier systems selected for field evaluation (rope net, rope net-unsynchronized strobe lights) were recommended following testing of behavioural barriers in the laboratory (OHRD Report 81-190-K). Alewife (adults), gizzard shad (juveniles and adults) and smelt (adults) were used as the test fish species. The 15 cm rope net spacing used in the field study was not evaluated in the laboratory studies but was recommended as a compromise spacing between tested 10 and 20 cm square spacings. The smaller size spacings (<10 cm) although more efficient in diverting fish than the 20 cm spacing would be more suseptible to frazil ice formation and would reduce water flow to the intake. The compromise 15 cm spacing was considered to be hydraulically more acceptable (July 22, 1980 meeting, File 962-NK21-07263) and was believed to be preferable in the higher turbidities associated with the field test site. It was hypothesized that any negative fish response to the large barrier panels would be less with 15 cm or smaller spacings than with larger spacings.

TABLE 3.2-3

SUMMARY OF FISH TRAJECTORY RELATIVE TO SYNCHRONIZED STROBE LIGHT-ROPE NET BARRIER FROM ACOUSTIC MONITORING PICKERING DIVERSION STUDY, 1982

NIGHT EXPERIMENTALS

DISTANCE FROM BARRIER (M)

TRAJECTORY DESCRIPTION	0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM BARRIER	5+	4	1	1
ERRATIC: TOWARDS/AWAY	17	16	10	0
PARALLEL/STATIONARY	36	29	11	3
SHALLOW SLOPE TOWARDS	22	29	28	17
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	18	22	50	79

+ - PERCENTAGE OF ECHOES IN THAT DEPTH RANGE WITH THE INDICATED TRAJECTORY

Illumination of the rope net with strobe light (approx 10 lux at the rope net) was recommended after the laboratory studies (OHRD Report 81-190-K) to reduce high night impingement (OHRD Reports 78-358-K, 78-475-K). In the laboratory studies the strobe lights were shown to significantly increase the barrier efficiency during night simulation tests. The illumination of fish behavioural barriers was supported by the results of other researchers (Ray et al 1976 and Hadderingh 1979).

The pilot field study structures were designed to incorporate the laboratory recommendations (OHRD Report C82-19-K). The rope nets were constructed with a 15 cm spacing and could be illuminated (10 lux at the rope net) by strobe lights. System design permitted coincident conducting of an experiment and a control and also permitted alternating the location of the experimental and control sites. The assessment of the effectiveness of the diversion systems was based upon the number of fish collected within a hoop net at the cod end of the collecting nets during the preliminary field tests in 1981. This fish collection apparatus was not efficient and did not collect all fish passing through the experimental and control structures. The 1981 fish catch data were not reliable and therefore could not be used in evaluating the effectiveness of the barrier systems. Redesigning the fish collection system with gill nets provided an adequate means of collecting fish passing through the structures from the lake. The use of the wing nets to the sides of the structures provided an indication of the number of fish within the vicinity of the diversion structures.

4.1 Smelt Tests

i) Rope Net Alone

The frame net smelt catches were extremely low (x=0) during the day and night experimental and control replicates. Higher wing net catches (x=120 smelt) indicated the presence of sufficient smelt stocks in the vicinity of the test structures for evaluation of the barrier systems. However, the smelt apparently could perceive the test structures and avoided the whole test system. Field data are not available to estimate the number of smelt avoiding the test structures.

The laboratory studies (OHRD Report 81-190-K) indicated similar smelt avoidance of the barrier structures and significant avoidance behaviour during low level light and simulated night conditions. The actual response of smelt to the rope net is not known. Field data are not available to indicate the behaviour of smelt at the rope net or in front of the control structure. Based on the smelt avoidance of the test system it is possible that smelt may avoid an intake system composed of large vertical components in the presence of minimal current velocities and low water turbidities without any behavioural barrier systems. However,it is probable that a rope net barrier would increase smelt avoidance.

In 1981 smelt comprised 58% (n=127 640 smelt) of the total fish impinged at Nanticoke TGS (OHTGD Report CTS-07015-21). The Nanticoke intake system was comprised of two submerged intakes in 10 m of water covered with intake caps 3.6 m above the intake pipes and extending 4.3 m beyond them. Water draw was angular through the entire water column into the intake pipes. Studies by James F. MacLaren (1979) indicated reasons for the high entrapment rate of smelt at Nanticoke GS. At Nanticoke GS entrapment of schooling species was increased by the presence of construction rubble in the proximity of the western intake which directed schooling fish species towards the intake. At the intake system fish could not detect and respond to the angular intake flow in time to prevent entrapment. The large intake openings did not permit fish to detect the presence of the intake structure until they were under the intake cap especially during periods of high turbidity and surface turbulence. Once under the intake cap fish were confined by the intake cap which prevented vertical escapement and by the lake bed. No major environmental discontinuities were present beneath the intake cap to permit fish species to detect and respond to the intake current once they were below the cap. Fish moving further under the intake cap encountered stronger intake currents, increasing the possibility of entrapment.

ii) Rope net - unsynchronized strobe light

The laboratory studies (OHRD Report 81-190-K) indicated projection of strobe light on the rope net barrier at night would increase smelt avoidance . However during the field tests smelt appeared to be attracted to the unsynchronized strobe lights. Smelt were caught in greater numbers (not significant) in the experimental frame nets than in the control frame nets. Individual smelt and smelt schools were observed to swim amongst the strobe lights. Whether the smelt entered the strobe area through the rope net or entered the strobe area through the side panels is not known. Light studies indicated the bank of unsynchronized strobe lights was producing a nearly continuous light (OHRD Report 82-353-K). Smelt attraction to the unsynchronized strobe lights is substantiated by laboratory results which indicate smelt attraction to a continuous light source (OHRD Report 82-353-K). However, smelt were also observed to be attracted to a single strobe light operating at night during light level measurement studies at the Bruce GS 'A' intake in 1980 (diver observations, no discernible current) and to swim amongst the synchronized strobe lights during 1982 alewife tests (diver observations) suggesting that strobe lights (synchronized or unsynchronized) will not effectively repel smelt in an intake barrier system.

4.2 Alewife Tests

i) Rope net alone

The field test data indicated a significant alewife avoidance response to the rope net (Table 4.2-1). Alewife passage was reduced 63 % by the rope net during daylight tests and 89 % during night tests. Combined day and night alewife passage was reduced 79 % with the rope net. Investigations by Stewart (1981) indicated flatfish (plaice (Platessa platessa), lemon sole (Microstomus kitt) and common dab (Limanda limanda)) were hesitant about passing through an unenergized net barrier during the day. He suggested the visual effect of the barrier was of great importance in inhibiting fish passage. This corresponds to the results of the laboratory studies (OHRD Report 81-190-K) which indicated larger or thicker diameter barrier components were more effective than smaller diameter barrier components. However, the laboratory studies (OHRD Report 81-190-K) indicated that the rope net would not be as effective at night as during the day unless illuminated by strobe light. The reason for the reversal between the field and laboratory night results is not known.

The difference between the laboratory and field results may possibly be explained by changes in alewife behaviour during the day and night test periods. Alewife tend to school near the lake bed during daylight periods, dispersing upward through the water column during darkness (Emery, 1973, OHRD Report 78-77-K). Alewife approaching the control structure during the day would have greater probability of encountering and diverting away from the collapsed rope net barrier than alewife approaching at night. The control frame net CUE values would be decreased if this occurred and would indicate reduced daylight barrier efficiency.

External sources of illumination were investigated to determine if they affected the test results. Conversations with field crew members indicated the barrier was not illuminated by any station light source. However, the barrier was illuminated by the full moon on clear nights. Statistical analysis of the catch data on clear and overcast nights with and without a full moon indicated the degree of cloud cover did not influence the catch results. Sample size (<5 full moons on clear nights) prohibited statistical analysis of the influence of moon phase on catch results. Since the rope net was illuminated by a full moon on a clear night on <5 occasions during the study period, the moon phase could thus be eliminated as a prime reason for the high night alewife catch reduction in the experimental frame nets.

Surface turbulence conditions were also investigated to determine if they contributed to the difference in the frame net results. It was hypothesized that wave action on the barrier may have created wave frequencies in the water column or a different noise level which contributed to the reduction in the experimental frame net catch. Field crew personnel indicated station noise was very discernible underwater at the test structures and appeared

Table 4.2-1

Rope Net Alone Alewife Passage
Pickering Diversion Study,1982

Replicate	Number	$\bar{x}$ experimental captures (E)	$\bar{x}$ control captures (C)	% reduction $\frac{C-E}{C} \times 100$
Daylight	41	2.6	7.0	63
Night	36	1.8	15.9	89
Combined*	82	2.3	10.9	79

* all light conditions

louder than underwater noise created at the structures through wave activity. Analysis of the frame net catch data during calm (<16 cm wave) and turbulent (>16 cm wave) conditions indicated no significant difference in CUE.

After the strobe lights were altered to a synchronized flash system all rope net alone experiments were performed at the west structure. The wing net CUE data was analyzed to determine if the catch results were influenced by differences in fish abundance between the east and west sides of the system. No significant difference was determined between the east and west structure wing net catches. The experimental and control water temperatures, turbidities and Secchi disc measurements were not significantly different during these test replicates.

The acoustic monitoring study data did not reveal alewife behaviour in close proximity (1 m) to the rope net or control structures. In the majority of the monitoring replicates alewife either moved parallel to the entrance to the structures or remained stationary in front of the structures. The acoustic monitoring equipment was not able to distinguish between either vertical and lateral fish movement (parallel) or stationary fish. The numbers of alewife were very variable and did not display any distinct avoidance behaviour to the rope net barrier. No relationship was apparent between the number of fish in front of the structures and the actual CUE for the monitored frame net.

ii) Rope net = unsynchronized strobe light

The laboratory studies (OHRD Report 81-190-K) indicated that the projection of strobe light on the rope net would increase alewife avoidance at night. Similar results were obtained with alewife as with smelt during the field tests. Alewife were attracted to the strobe lights and were captured in significantly greater numbers in the night experimental frame and wing nets than in the control nets. The attraction of the alewife to the unsynchronized strobe lights probably does not reflect an attraction to strobe light but rather to a nearly continuous light source (OHRD Report 82-353-K). The attraction to the light source was strong enough to negate the effectiveness of the rope net in diverting alewife at night.

iii) Rope net = synchronized strobe lights

The synchronized strobe light system was more effective in reducing the alewife catch in the experimental frame net than was the unsynchronized strobe light system. However, the experimental frame net CUE was not significantly different from the control frame net CUE. It was suspected that far-field attraction may still be occurring, since at some unknown distance from the strobe lights the light would appear continuous. The appearance of continuous light probably did not occur in the small circular pools (5.5 m) during the laboratory tests (OHRD Report 81-190-K).

The experimental and control frame net catches were not significantly different at any of the flash rates tested (48-455 fpm). Alewife passage was only reduced during the 3 higher flash rate (>400 fpm) replicates. The use of the acoustic monitoring system did not reveal any distinct behavioural alewife response to the illuminated rope net at any of the flash rates. Alewife movement was either primarily parallel to the entrance to the structures or stationary in front of the structures.

5.0) CONCLUSIONS

The results of this study indicated the rope net barrier without illumination was the most effective barrier system (of those tested) for the exclusion of alewife at the Pickering pilot diversion test site. It is not known whether the rope net is an effective smelt diversion system since smelt avoided the diversion structures. However, it is probable that the rope net would not have any negative effect since the rope nets add to the physical structure increasing the possibility of fish detection and diversion.

Strobe lights (as tested) are not required to illuminate the rope net barriers since the rope net barrier efficiency decreased when illuminated by the strobe lights (synchronized or unsynchronized). The use of strobe lights creates the potential of far-field attraction of pelagic fish to a continuous light source which could increase the number of fish approaching intakes.

5.0) Summary

1) Smelt displayed a distinct avoidance behaviour to the experimental and control structures during day and night replicates when no light sources were used. This prevented evaluation of the effectiveness of the rope net in diverting smelt.

2) Alewife and smelt were attracted to the unsynchronized strobe lights during the night rope net - unsynchronized strobe light test replicates. Studies indicated the combined unsynchronized strobe lights were producing a nearly continuous light instead of the required typical flashing strobe light. The attraction to the light was strong enough to negate the effectiveness of the rope net in diverting alewife and the structures in diverting smelt. It is not known whether the fish perceived the diversion structures when they passed through the rope nets. During the alewife rope net - synchronized strobe light tests smelt did not avoid the test structure.

3) Alewife passage through the unilluminated rope net was reduced (relative to controls) by 63% during the day , by 89% at night and by 79% over all light conditions. The reason for the higher night effectiveness is not known. The effectiveness of the rope net could not be attributed to surface turbulence conditions, external illumination of the rope net during night

replicates, test location (east vs west structure), or to differences in water temperature, turbidity and Secchi disc values. It is possible that the higher night effectiveness is related to the diurnal behaviour patterns of alewife. The acoustic monitoring study indicated the majority of fish remained stationary in front of the structures or moved parallel to the structure entrance.

4) No significant differences could be determined between the experimental and control frame net catches during alewife rope net - synchronized strobe light (48-455 fpm) test replicates. However, alewife passage was reduced in replicates with flash rates >400 fpm. No distinct alewife avoidance behaviour could be detected at any of the tested strobe light flash rates (48-455 fpm) during acoustic monitoring studies.

5) The strobe light lamp failure rate was high. It was not known whether lamp failure adversly affected the test replicate results.

6.0) Recommendations

1) The rope net, as tested, proved to be an effective (79 %) means to exclude alewife from the Pickering pilot test facilities. The alewife laboratory studies with similar rope nets indicated an 87% effectiveness. Smelt avoidance of the rope net could not be evaluated however, since smelt avoided the test structures it is probable that smelt avoidance would be increased with the rope net. The rope net fish barrier system appears to be a workable system for intake structures where it will not be detrimental to station operation, where current velocities in front of the rope net will permit fish escape, and where water turbidity is low enough to permit the fish to visually perceive the barrier. It is not known whether the effectiveness of the barrier will be maintained with larger barrier panels and at increased water depths.

2) Strobe lights are not recommended to be used in conjunction with the rope net since the rope net was more effective in diverting alewife when not illuminated. Far field attraction may also lead fish to the intake structure possibly increasing the intake of fish.

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REFERENCES

1. Emery, A.R., 1973. Preliminary comparisons of day and night habits of freshwater fish in Ontario lakes. J. Fish. Res. Board Can. 30:761-774.

2. Hadderingh, R.H., 1979. Fish intake mortality at power stations. The problems and its remedy. Hydrobiol. Bull. 13:83-93.

3. James F. MacLaren Ltd., 1979. Fish entrapment as it relates to their densities and movements around cooling water intake structures. Report to Ontario Hydro. J.R. Foster. Volume 1.

4. Ontario Hydro Nuclear Generation Division Report No. RMEP-IR-07000-2. NGD Annual Environmental Summary, 1980.

5. Ontario Hydro Nuclear Generation Division Report No. RMEP-IR-07000-4. NGD Annual Environmental Summary, 1981.

6. Ontario Hydro Research Division Report 78-77-K. Diurnal variation in entrapment of fish at Pickering GS. H. Balesic, February 16, 1978.

7. Ontario Hydro Research Division Report 78-358-K. Effectiveness of the Pickering GS fish barrier - 1977. Studies and final report. H.Balesic, July 28, 1978.

8. Ontario Hydro Research Division Report 78-475-K. Alewife and gizzard shad impingement at Pickering GS from 1975-7. P.H. Patrick, December 19, 1978.

9. Ontario Hydro Research Division Report 79-87-K. Acoustic survey methods . H. Balesic, May 31, 1979.

10. Ontario Hydro Research Division Report 79-104-K. Response of gizzard shad to strobe light at different current velocities. P.H. Patrick, September 9, 1980.

11. Ontario Hydro Research Division Report 80-82-K. Effectiveness of chains, nets and fences in diverting fish. Progress Report. P.H. Patrick, January 15, 1980.

12. Ontario Hydro Research Division Report 80-156-K. Effectiveness of a chain net strobe light, shad exclusion scheme. P. H. Patrick, August 5, 1980.

13. Ontario Hydro Research Division Report 80-238-K. Response of gizzard shad to strobe light at various current velocities. P.H. Patrick, September 9, 1980.

14. Ontario Hydro Research Division Report 81-190-K. Responses of fish to diversion barriers. P.H. Patrick, July 29, 1981.

15. Ontario Hydro Research Division Report C82-19-K. Bruce GS 'B' fish diversion pilot test program, Pickering GS Progress Report, 1981. R.W.Sheehan, December 31, 1982.

16. Ontario Hydro Research Division Report 82-177-H. Failure of experimental fish diversion strobes. M.K.G. Stelter, April 26, 1982.

17. Ontario Research Division Report 82-353-K. Strobe flash output measurements at the Pickering GS fish diversion Barrier. P.H. Patrick, August 3, 1982.

18. Ontario Hydro Research Division Report 82-376-K. Synchronization of fish diversion strobes. M.K.G. Stelter, December 31, 1982.

19. Ontario Hydro Thermal Generation Division Report CTS-07015-21. Fish impingement results from Ontario Hydro thermal generating stations, 1981.

20. Ray, S.S., R.L. Snipes and D.A. Tomjanovich, 1976. A state-of-the-art report on intake technologies. Tennessee Valley Authority Power Research Staff pp 1-75.

21. Stewart, P.A.M.,1981. An investigation into the reactions of fish to electrified barriers and bubble curtains. Fish. Res., 1:3-22.

Appendix A

Diversion System Structure Design
Pickering Diversion Study, 1982

Design and Construction Branch

Civil Layout

Drawing Number	Title
NK29-DOH-27990-0001	Bruce GS 'B' C.W. Intake Fish Management System Structure General Arrangement (Field Test At Pickering GS)
NK29-DOH-27990-0002	Bruce GS 'B' C.W. Intake Fish Management System Structures Plans and Sections (Field Test At Pickering GS)
NK29-DOH-27990-0003	Bruce GS 'B' C.W. Intake Fish Management System Structures Details (Field Test At Pickering GS)

Generation Projects Division
Construction Projects - Field

Drawing Number	Title
NK29-DCH-27990-SK1	Pickering GS 'B', Pickering 'A' Intake Channel Swing Stage Support Plan and Details
NK29-DDH-27990-SK2	Bruce GS Pickering A Intake Channel Fish Net Frame And Column Extension Arrangement and Details

Appendix B

FISH CATCH (2 HR CUE) DATA SUMMARY
PICKERING DIVERSION STUDY, 1982

	TIME				FISH CATCH							
					FRAME NETS				WING NETS			
					EAST		WEST		EAST		WEST	
DATE	START	FINISH	REPLICATE	FISH	LAKE	SHORE	LAKE	SHORE	LAKE	SHORE	LAKE	SHORE
APR 26	1000	1215	E RN	S	0	0	0	0	1*		0	
APR 26	1430	2000	E RN	S	0	0	0	0	0		1	
APR 26	2000	2200	E RN	S	0	0	0	0	23		32	
APR 26	2200	2400	E RN	S	0	0	0	0	17		3	
APR 27	0000	1000	E RN	S	0	0	0	0	10		108	
APR 27	1130	1330	W RN	S	0	0	0	0	0		1	
APR 27	1400	1600	W RN	S	0	0	0	0	0		0	
APR 27	1630	2230	W RN	S	0	0	0	0	13		16	
APR 27	2100	2300	W RN	S	0	0	0	0	191		27	
APR 27	2300	0130	W RN	S	0	0	0	0	38		29	
APR 28	0200	0915	W RN	S	1	0	1	0	146		87	
APR 28	0945	1145	W RN	S	0	0	0	0	1		3	
APR 28	1215	1415	W RN	S	0	0	0	0	0		0	
APR 28	1430	2000	W RN	S	0	0	0	0	2		0	
APR 28	2030	2230	W RN	S	0	0	0	0	56		106	
APR 28	2300	0100	W RN	S	0	0	0	0	11		44	
APR 29	0130	0930	W RN	S	0	0	0	0	16		112	
APR 29	0940	1140	W RN	S	0	0	0	0	1		5	
APR 29	1200	1400	W RN	S	0	0	0	0	1		1	
APR 29	1415	2000	W RN	S	0	0	0	0	2		3	
APR 29	2030	2230	W RN	S	0	0	0	0	32		12	
APR 29	2300	0100	W RN	S	0	0	0	0	129		56	
APR 30	0130	0930	W RN	S	0	0	0	0	16		54	
APR 30	0945	1145	W RN	S	0	0	0	0	0		0	
APR 30	1200	1415	W RN	S	0	0	0	0	0		0	
APR 30	1430	2000	W RN	S	0	0	0	0	0		1	
APR 30	2030	2230	W RN	S	0	0	0	0	11		9	
APR 30	2300	0100	W RN	S	0	0	0	0	52		78	
MAY 03	1500	1950	W RN	S	0	0	0	0	0		0	
MAY 03	2010	2210	W RN	S	0	0	0	0	2		2	
MAY 03	2215	0015	W RN	S	0	0	0	0	8		9	
MAY 04	0030	0900	W RN	S	0	0	0	0	6		3	
MAY 04	0930	1130	W RN	S	0	0	0	0	0		0	
MAY 04	1145	1345	W RN	S	0	0	0	0	0		1	
MAY 04	1400	1950	W RN	S	0	0	0	0	0		0	
MAY 04	2000	2200	W RN	S	0	0	0	0	28		19	
MAY 04	2210	0010	W RN	S	0	0	0	0	51		235	
MAY 05	0020	0920	W RN	S	0	0	0	0	24		23	
MAY 05	0930	1330	W RN	S	0	0	0	0	0		1	
MAY 05	1400	2000	W RN	S	0	0	0	0	1		0	
MAY 05	2015	0045	W RN	S	0	0	0	0	47		6	

MAY 06	0100	1000	W RN	S	0	0	0	0	16		52		
MAY 06	1200	2000	E RN	S	0	0	0	0	1		2		
MAY 06	2015	0015	E RN	S	0	0	0	0	158		131		
MAY 07	0030	0915	E RN	S	0	0	0	0	49		77		
MAY 07	0930	2000	E RN	S	0	0	0	0	1		1		
MAY 07	2015	2215	E RN	S	0	0	0	0	36		12		
MAY 07	2225	0025	E RN	S	1	0	0	0	18		27		
MAY 10	1000	2200	W RN	S	0	0	0	0	0	0	1	9	
MAY 10	2210	1110	W RN	S	0	0	0	0	0	5	3	0	
MAY 11	1200	2330	E RN	S	0	0	0	0	1	0	1	1	
MAY 11	2345	1230	E RN	S	0	0	0	0	9	6	12	20	
MAY 12	1300	0100	W RN	S	0	0	0	0	1	1	1	2	
MAY 13	0100	2000	W RN	S	1	0	0	0	46	45	62	80	
MAY 13	2030	0930	E RN	S	0	0	1	0	25	15	79	52	
MAY 14	0930	0000	E RN	S	0	0	0	0	1	1	1	1	
MAY 17	1000	2200	W RN	S	0	0	0	0	1	1	1	1	
MAY 17	2215	0015	W US	S	0	0	2	0	9	0	62	0	
MAY 18	1030	2230	E RN	S	0	0	0	0	1	1	2	1	
MAY 18	2245	0945	E US	S	1	0	0	0	5	6	3	3	
MAY 19	2130	1100	E US	S	1	0	0	0	5	5	0	0	
MAY 20	1100	1000	W RN	S	0	0	0	0	4	12	20	20	
MAY 21	1030	2000	W US	S	0	0	0	0	1	0	0	1	
MAY 21	2015	0015	W US	S	0	0	5	0	0	0	2	0	
MAY 25	1045	1415	E RN	A	0	0	2	0	2	0	2	0	
MAY 25	1430	2000	E RN	A	0	0	10	7	1	1	80	32	
MAY 25	2020	2220	E US	A	132	33	51	33	161	76	105	123	
MAY 25	2245	0045	E US	A	134	57	31	8	342	67	104	106	
MAY 26	1030	2000	W RN	A	0	0	0	0	23	4	43	8	
MAY 26	2015	2215	W US	A	9	3	86	26	39	25	133	31	
MAY 26	2230	0045	W US	A	24	8	231	87	34	71	101	31	
MAY 27	1100	2000	E RN	A	0	0	1	1	1	2	4	5	
MAY 27	2015	2215	E US	A	134	21	123	47	58	171	24	155	
MAY 31	0930	1130	E US	A	0	0	1	0	4	0	7	0	
MAY 31	1140	1340	E US	A	0	0	0	0	5	0	5	2	
MAY 31	1400	2000	E RN	A	0	0	40	13	3	6	6	24	
MAY 31	2015	2215	E US	A	29	11	61	17	41	167	56	129	
MAY 31	2230	0030	E US	A	139	70	9	10	104	42	87	190	
JUN 01	1045	1345	W RN	A	2	0	0	0	143	67	25	9	
JUN 01	1400	1930	W RN	A	0	0	1	0	15	43	20	74	
JUN 01	1945	2245	W US	A	56	21	159	84	97	161	106	123	
JUN 02	1030	1420	E RN	A	0	0	1	0	3	9	93	33	
JUN 02	1430	2030	E RN	A	0	0	75	39	33	130	26	176	
JUN 03	1000	1345	E RN	A	0	0	0	0	4	0	6	2	
JUN 03	1400	1930	E RN	A	0	0	0	0	4	15	1	19	
JUN 03	2000	2200	E US	A	45	19	14	7	48	113	66	89	
JUN 03	2230	0030	E US	A	87	47	54	9	172	53	67	203	
JUN 04	0950	1330	W RN	A	0	0	0	0	4	0	1	1	
JUN 04	1345	1945	W RN	A	1	0	0	0	1	1	1	2	
JUN 04	2015	2215	W US	A	14	4	59	26	68	152	42	149	
JUN 04	2245	0045	W US	A	18	9	92	47	43	146	41	125	
JUN 07	1030	1345	W RN	A	2	1	0	0	14	53	38	52	
JUN 07	1400	2000	W RN	A	1	1	0	0	79	39	89	34	
JUN 07	2015	0115	W RN	A	27	10	4	4	85	115	71	67	
JUN 08	1930	2130	E RN	A	1	0	76	26	82	149	66	73	
JUN 08	2145	2345	E RN	A	2	0	89	35	54	70	81	172	

JUN 09	0030	1000	E RN	A	1	0	17	4	25	60	44	23
JUN 09	1245	1930	W RN	A	0	0	1	0	3	0	6	1
JUN 09	1945	2145	W RN	A	16	1	1	0	56	62	61	101
JUN 09	2200	0000	W RN	A	34	9	0	0	89	61	87	116
JUN 10	0015	0915	W RN	A	2	1	1	1	27	10	44	20
JUN 10	1030	1345	E RN	A	14	7	25	8	81	37	63	29
JUN 10	1400	1945	E RN	A	0	1	1	0	6	25	11	56
JUN 10	2000	2200	E RN	A	0	0	51	12	43	193	28	151
JUN 10	2215	0030	E RN	A	1	0	61	32	79	164	93	145
JUN 11	0045	1400	E RN	A	1	1	1	1	40	12	15	65
JUN 11	1415	1945	E RN	A	0	0	1	0	10	47	5	20
JUN 11	2000	2200	E RN	A	0	0	7	2	40	64	29	33
JUN 14	1120	1320	W RN	A	0	0	0	0	2	1	61	0
JUN 14	1330	1945	W RN	A	1	1	0	0	13	2	19	3
JUN 14	2000	0000	W RN	A	8	0	1	0	25	73	14	15
JUN 15	0030	1030	W RN	A	1	1	0	0	21	3	17	3
JUN 15	1245	1000	E RN	A	1	0	2	1	5	0	1	1
JUN 16	1230	2000	E RN	A	0	0	1	0	2	20	2	21
JUN 16	2000	0100	E RN	A	0	0	1	0	3	5	7	6
JUN 17	0130	1330	E RN	A	0	0	0	0	13	23	8	25
JUN 17	1345	1930	E RN	A	0	0	0	0	1	1	1	0
JUN 17	1945	2200	E RN	A	0	0	4	0	2	22	4	9
JUN 17	2215	0945	E RN	A	5	1	1	1	1	1	1	1
JUN 18	1145	1945	W RN	A	0	0	0	0	1	0	1	0
JUN 18	2000	0000	W RN	A	0	0	1	0	7	6	12	11
JUN 21	0015	1145	W RN	A	0	1	0	0	1	10	7	7
JUN 21	2045	2345	W RN	A	0	0	0	0	10	1	1	9
JUN 22	2000	0000	W RN	A	1	0	1	1	7	4	21	16
JUN 23	0015	1000	W RN	A	0	1	0	0	1	3	3	21
JUN 23	2000	0000	E RN	A	0	0	2	0	17	29	8	16
JUN 24	0030	1000	E RN	A	0	0	1	1	1	15	5	44
JUN 24	2000	0930	E RN	A	0	0	2	1	2	4	1	1
JUN 25	1000	2000	E RN	A	0	0	0	0	1	1	1	1
JUN 25	2030	0930	E RN	A	0	0	1	1	1	1	1	1
JUN 28	2000	0015	E RN	A	1	1	1	1	11	65	17	100
JUN 29	0030	1000	E RN	A	1	1	1	1	1	18	1	20
JUN 29	1030	2000	E RN	A	0	0	0	0	13	65	2	7
JUN 29	2015	2345	E RN	A	0	0	1	0	17	59	16	41
JUN 30	0000	1000	E RN	A	1	1	0	0	15	49	21	60
JUL 02	0045	1000	W RN	A	0	0	0	0	14	1	6	21
JUL 05	1120	1945	W RN	A	1	0	0	0	1	1	18	6
JUL 05	2000	0000	W SS	A	9	1	1	1	38	17	25	20
JUL 06	0015	0945	W SS	A	1	1	1	1	9	6	3	21
JUL 06	1000	2000	W RN	A	0	0	0	0	74	37	16	2
JUL 06	2015	0015	W SS	A	17	17	7	3	13	15	42	44
JUL 07	0030	0930	W SS	A	25	8	8	4	60	26	84	34
JUL 07	1000	2000	W RN	A	8	1	1	1	15	10	0	2
JUL 07	2015	0915	W SS	A	4	2	3	2	2	6	2	5
JUL 08	0930	2030	W RN	A	1	1	1	1	9	19	1	0
JUL 08	2030	0030	W SS	A	1	0	33	17	12	2	25	17
JUL 09	0045	0930	W SS	A	0	0	1	2	20	0	4	5
JUL 13	1000	1945	W RN	A	0	1	1	1	1	0	1	1
JUL 13	2000	0015	W RN	A	1	1	1	0	4	1	1	5
JUL 14	1000	1945	W RN	A	0	0	1	1	0	0	1	1
JUL 14	0030	0930	W RN	A	1	0	6	2	3	9	1	2

JUL 14	2000	0000	W RN	A	19	2	7	2	36	17	1	1
JUL 15	0015	0900	W RN	A	10	3	12	7	1	1	1	0
JUL 15	2040	0020	W RN	A	71	22	9	5	2	1	2	2
JUL 16	0040	0945	W RN	A	44	15	4	2	15	10	1	1
JUL 16	1000	1930	W RN	A	5	6	9	4	5	7	8	3
JUL 16	2000	0100	W SS	A	62	25	61	34	26	26	18	8
JUL 20	1015	2000	W RN	A	3	1	0	1	0	1	1	1
JUL 20	2030	0100	W SS	A	17	16	40	15	53	44	32	96
JUL 21	0110	0910	W RN	A	0	1	4	4	1	5	1	1
JUL 21	0930	2030	W RN	A	0	0	3	1	60	33	33	19
JUL 21	2045	0030	W SS	A	7	2	17	4	3	1	1	1
JUL 22	0045	0930	W SS	A	9	4	30	8	106	70	67	55
JUL 22	1000	2045	W RN	A	27	7	17	6	45	50	5	16
JUL 22	2100	0130	W SS	A	54	26	85	48	63	194	5	16
JUL 23	0200	1000	W SS	A	60	15	56	34	32	32	10	11
JUL 23	1030	2000	W RN	A	12	3	7	7	96	127	65	66
JUL 23	2000	0100	W SS	A	12	8	14	10	23	38	21	33
JUL 26	0930	2030	W RN	A	29	8	45	22	71	70	21	32
JUL 26	2045	0045	W SS	A	24	5	49	27	32	33	39	15
JUL 27	0930	1945	W RN	A	19	11	18	9	45	57	13	17
JUL 27	2000	0000	W SS	A	89	45	21	15	153	141	63	27
JUL 28	0030	0940	W SS	A	56	30	14	9	5	11	17	27
JUL 28	0940	1945	W RN	A	3	2	0	0	2	1	6	17
JUL 28	2000	0000	W SS	A	11	14	17	1	31	28	17	6
JUL 29	0015	0930	W SS	A	38	22	7	5	92	90	11	23
JUL 29	1000	2030	W RN	A	12	6	1	0	121	97	47	24
JUL 29	2045	0015	W SS	A	50	40	85	44	67	85	22	17
JUL 30	0030	0930	W SS	A	62	12	10	26	63	86	161	150
JUL 30	0930	2015	W RN	A	41	13	1	1	7	3	94	90

EXPERIMENT	FISH	CATCH
E-east	A-alewife	L-lake
W-west	S-smelt	S-shore
RN-rope net		
US-unsynchronized strobe and rope net		
SS-synchronized strobe and rope net		

+ - direction of fish from lake or shore not differentiated until May 10

APPENDIX C

WATER TEMPERATURE (°C), TURBIDITY (NTU) AND SECCHI DISC (M)
DATA SUMMARY - PICKERING DIVERSION STUDY, 1982

	Time				Temperature						Turbidity						Secchi	
					EAST			WEST			EAST			WEST			EAST	WEST
Date	Start	Finish	Replicate	Fish	S	M	B	S	M	B	S	M	B	S	M	B		
820427	1130	1330	MN	S	16.0	7.0	6.0	16.0	7.0	6.0	4.5	5.0	5.5	4.0	8.0	9.0	1.2	1.2
820427	1400	1600	MN	S	10.0	7.0	6.5	12.0	7.5	7.0	-	-	-	-	-	-	1.5	1.5
820427	1630	2230	MN	S	10.0	7.0	6.5	12.0	7.5	7.0	1.1	2.8	1.2	1.5	1.2	1.1	1.7	1.7
820427	2100	2300	MN	S	8.5	7.5	6.0	9.9	7.5	6.0	1.2	-	-	1.3	-	-	-	-
820427	2300	0130	MN	S	8.5	7.5	6.0	9.0	7.5	6.0	1.7	1.9	2.5	1.9	2.1	1.4	-	-
820428	0200	0915	MN	S	8.5	8.0	5.5	9.0	7.0	6.0	3.2	3.6	3.9	3.4	-	-		
820428	0945	1145	MN	S	8.0	7.0	6.0	8.0	7.0	6.0	2.2	3.1	3.4	3.1	2.1	2.2	1.7	1.7
820428	1215	1415	MN	S	7.0	7.0	6.5	7.0	7.0	6.0	2.5	2.6	2.6	2.4	3.0	2.9	1.7	1.7
820428	1430	2000	MN	S	7.0	7.0	6.0	7.0	7.0	6.0	2.9	2.5	2.7	2.0	3.0	2.7	1.8	1.8
820428	2030	2230	MN	S	10.5	7.5	6.0	10.0	9.0	7.0	1.9	1.6	3.1	2.3	2.1	2.2	-	-
820428	2300	0100	MN	S	9.0	6.0	6.0	8.0	6.0	6.0	3.1	1.8	2.2	2.4	1.9	2.5	-	-
820429	0130	0930	MN	S	8.0	6.0	6.0	8.0	6.0	6.0	3.0	4.3	4.3	3.1	2.9	4.8	1.8	1.8
820429	0940	1140	MN	S	8.5	5.5	5.5	8.5	5.5	5.5	1.9	2.6	2.0	2.3	2.6	2.2	1.8	1.8
820429	1200	1400	MN	S	12.0	7.0	6.0	13.0	10.0	6.0	2.5	2.7	3.6	2.8	2.8	2.7	1.5	1.4
820429	1415	2000	MN	S	15.0	8.0	8.5	16.0	8.0	7.0	2.6	3.0	3.3	2.6	3.0	5.1	1.6	1.6
820429	2030	2230	MN	S	9.0	8.0	7.5	12.0	7.0	7.0	2.2	1.6	1.9	1.8	2.0	1.7	-	-
820429	2300	0100	MN	S	9.0	9.0	7.0	12.0	7.0	7.0	1.8	3.5	3.3	2.1	1.9	2.5	-	-
820430	0130	0930	MN	S	8.0	6.0	6.0	8.0	6.0	6.0	1.4	1.1	1.8	0.9	1.3	1.0	1.6	1.6
820430	0945	1145	MN	S	12.2	6.0	6.0	12.2	6.0	6.0	1.2	2.2	2.0	1.8	1.4	1.0	1.6	1.6
820430	1200	1415	MN	S	12.0	6.0	6.0	12.0	6.0	6.0	1.6	1.1	1.2	1.5	1.3	1.4	1.6	1.6
820430	1430	2000	MN	S	15.5	7.0	6.2	16.0	10.0	7.0	1.9	1.6	1.8	2.1	1.8	1.8	1.4	1.4
820430	2030	2230	MN	S	10.0	7.2	5.5	9.0	7.0	6.0	2.4	2.4	2.6	2.2	1.6	1.9	-	-
820430	2300	0100	MN	S	7.0	6.0	5.0	7.5	5.0	5.0	2.2	1.6	1.6	2.3	1.4	1.4	-	-
820503	1500	1950	MN	S	13.0	6.0	6.0	12.0	6.0	6.0	1.4	2.2	2.1	2.9	3.6	1.9	2.5	2.5
820503	2010	2210	MN	S	13.0	8.0	6.0	13.0	7.0	6.0	1.7	2.1	1.9	1.7	2.2	1.8	-	-
820503	2215	0015	MN	S	12.0	7.0	6.0	14.0	7.5	6.0	1.4	2.2	1.5	1.6	1.7	1.6	-	-
820504	0030	0900	MN	S	11.0	7.0	6.0	13.0	7.0	6.0	1.1	1.1	1.2	1.2	1.4	1.3	-	-
820504	0930	1130	MN	S	11.0	6.0	6.0	11.0	6.0	6.0	2.1	1.9	2.6	1.5	1.9	1.1	2.0	2.0
820504	1145	1345	MN	S	11.0	7.0	6.0	11.0	6.5	6.0	2.0	2.3	2.7	1.3	1.5	1.9	2.2	2.2
820504	1400	1950	MN	S	14.0	6.5	6.0	14.5	6.5	6.0	1.8	2.9	2.1	2.2	2.3	1.9	2.0	2.0
820504	2000	2200	MN	S	10.2	6.2	6.0	13.0	6.0	5.5	1.4	1.8	1.5	1.9	1.6	1.5	-	-
820504	2210	0010	MN	S	9.0	5.8	5.2	11.0	5.5	5.0	1.7	1.4	1.4	1.9	1.7	1.7	-	-
820505	0020	0920	MN	S	7.5	5.0	5.0	9.0	5.0	5.0	1.7	2.1	1.3	1.4	1.3	1.5	-	-
820505	0930	1330	MN	S	7.5	7.0	6.0	7.5	6.5	5.5	1.6	2.5	1.8	1.8	1.9	2.2	2.5	2.5
820505	1400	2000	MN	S	8.0	7.5	6.5	7.5	7.0	6.0	2.6	1.5	1.5	1.3	1.2	1.3	2.5	2.5
820505	2015	0045	MN	S	8.0	8.0	7.8	8.0	7.8	7.5	1.7	1.5	1.3	1.2	1.4	1.3	-	-
820506	0100	1000	MN	S	8.0	7.8	7.5	8.0	7.8	7.5	1.0	1.1	1.1	1.0	1.1	1.1	-	-
820510	1000	2200	MN	S	10.0	5.0	5.5	10.5	5.0	5.5	2.0	1.7	1.4	2.1	2.1	1.8	3.0	3.0
820510	2210	1100	MN	S	15.0	7.5	7.0	16.0	7.8	7.0	1.4	1.4	1.5	1.9	1.6	1.4	2.5	2.5
820512	1300	0100	MN	S	9.0	9.0	9.0	9.0	9.0	9.0	1.8	1.7	1.7	1.8	1.8	2.7	2.7	2.7
820513	0100	2000	MN	S	10.0	7.8	7.0	11.5	8.3	7.0	1.8	1.7	1.5	1.8	2.3	1.7	2.5	2.5
820517	1000	2200	MN	S	10.5	9.0	7.0	10.5	7.5	6.5	1.3	1.4	1.4	1.3	1.6	1.6	3.0	3.0
820520	1100	1000	MN	S	11.0	10.0	8.0	11.0	10.0	8.0	2.4	1.8	1.8	2.4	2.3	2.0	-	-
820526	1030	2000	MN	A	11.0	8.0	7.5	11.0	8.0	8.0	1.8	2.3	1.7	1.5	1.8	1.7	2.3	2.3
820601	1045	1345	MN	A	11.0	11.0	10.0	11.0	11.0	10.0	1.8	1.6	1.8	1.4	1.5	1.2	2.5	2.5
820601	1400	1930	MN	A	12.0	11.0	11.0	14.0	11.2	11.0	1.6	2.0	1.5	1.5	1.7	3.7	2.5	2.5

820604	0950	1330	WN	A	11.0	11.0	11.0	11.0	11.0	11.0	1.3	1.4	1.5	1.0	0.9	2.7	2.5	2.5
820604	1345	1945	WN	A	11.5	11.5	11.5	11.5	11.5	11.5	1.1	1.8	1.8	1.1	1.6	1.5	2.5	2.0
820607	2015	0115	WN	A	16.0	13.5	13.0	16.5	14.0	13.5	1.5	1.6	1.6	1.0	1.5	1.3	2.0	2.0
820607	1400	2000	WN	A	15.0	13.0	12.2	16.0	13.0	12.0	2.0	1.5	1.9	1.8	1.8	2.0	2.0	2.0
820607	1030	1345	WN	A	12.5	12.5	12.2	14.0	12.7	12.2	3.0	2.7	3.2	1.8	3.1	3.2	1.7	1.7
820609	1245	1930	WN	A	12.2	12.2	12.0	12.2	12.2	12.0	1.1	2.2	1.4	1.3	1.2	0.9	2.2	2.2
820609	1945	2145	WN	A	17.0	16.0	14.0	17.0	16.5	14.0	1.2	1.7	1.7	1.2	1.6	1.8	-	-
820609	2200	0000	WN	A	16.0	14.0	14.0	16.0	13.5	13.5	1.3	1.3	1.8	1.2	1.5	1.6	-	-
820610	0015	0915	WN	A	16.0	13.0	13.0	16.0	13.0	13.0	0.9	0.9	1.3	0.9	1.0	0.8	-	-
820614	1120	1320	WN	A	18.0	13.0	12.5	18.0	13.0	12.5	2.2	1.7	2.0	1.4	2.3	1.8	2.2	2.2
820614	1330	1945	WN	A	19.0	13.5	13.0	19.0	15.0	13.0	1.2	1.8	1.7	1.5	1.5	1.8	2.0	2.0
820614	2000	0000	WN	A	16.5	14.0	15.0	17.5	13.5	14.0	2.3	2.1	2.1	2.0	2.3	1.9	-	-
820615	0030	1030	WN	A	15.0	14.5	13.0	15.0	13.5	13.0	1.0	1.5	-	1.2	1.0	1.3	1.8	1.8
820618	1145	1945	WN	A	14.0	10.0	9.0	14.0	10.0	9.0	1.1	1.1	0.9	1.3	1.3	1.4	2.8	2.8
820614	2000	0000	WN	A	19.0	14.0	13.5	18.5	14.5	14.0	1.9	1.4	1.8	1.5	1.6	2.1	-	-
820621	2045	2345	WN	A	14.2	12.0	11.0	14.0	12.0	11.0	1.8	2.2	2.2	1.4	1.7	1.7	-	-
820621	0015	1145	WN	A	14.0	10.0	9.8	14.2	9.8	9.0	1.4	1.4	1.2	1.7	1.4	1.8	-	-
820622	2000	0000	WN	A	15.0	14.0	14.0	15.3	13.5	13.5	1.6	1.4	1.2	1.8	1.1	1.3	-	-
820623	0015	1000	WN	A	12.0	10.8	9.5	12.0	11.0	9.5	1.5	1,4	1.2	1.5	1.4	1.9	-	-
820702	0045	1000	WN	A	8.3	5.8	5.8	11.0	5.8	5.8	1.5	1.2	1.9	1.6	2.1	2.3	-	-
820705	1120	1945	WN	A	10.0	10.0	7.5	11.0	8.3	7.8	2.9	2.7	2.0	2.8	1.9	2.1	1.8	1.7
820706	1000	2000	WN	A	13.0	11.0	10.0	12.5	12.0	9.5	2.0	2.0	1.5	1.9	1.6	1.8	2.6	2.8
820707	1000	2000	WN	A	15.3	14.8	12.7	15.2	13.8	11.8	1.9	1.9	1.4	1.9	2.7	2.1	2.5	2.5
820708	0930	2030	WN	A	12.0	8.5	7.5	14.0	8.5	8.0	2.8	3.2	2.0	2.0	1.9	2.5	2.4	2.3
820713	1000	1945	WN	A	8.0	7.0	6.5	11.0	7.0	7.0	2.0	2.1	1.4	2.0	1.8	1.4	-	-
820713	2000	0015	WN	A	10.5	9.0	6.5	9.5	8.5	6.5	1.9	2.7	2.2	1.7	2.3	2.1	-	-
820714	1000	1945	WN	A	9.0	8.5	7.0	12.0	10.0	8.0	0.9	0.9	0.9	1.0	1.0	1.1	2.0	2.0
820714	0030	0930	WN	A	10.0	6.5	6.0	11.0	5.5	5.0	1.8	2.0	1.8	1.0	1.2	1.0	-	-
820714	2000	0000	WN	A	10.5	9.0	6.5	11.0	9.5	6.5	2.1	2.7	3.2	2.1	2.3	2.7	-	-
820715	0015	0900	WN	A	13.0	12.0	8.5	13.0	11.0	7.0	1.5	1.7	4.8	1.5	1.7	2.1	-	-
820715	2040	0020	WN	A	15.5	14.0	9.0	15.0	14.0	9.0	1.9	1.8	2.2	2.3	2.2	1.4	-	-
820716	0040	0945	WN	A	11.0	9.0	8.0	16.5	11.0	9.0	1.1	1.0	1.6	0.8	1.6	1.1	-	-
820716	1000	1930	WN	A	16.0	11.0	8.0	17.0	13.0	10.0	1.3	1.0	1.8	1.2	1.2	1.2	-	-
820720	1015	2000	WN	A	9.0	7.5	6.5	9.0	8.0	6.5	1.4	1.5	1.5	1.1	1.5	1.6	-	-
820531	1400	1200	EN	A	19.0	11.3	11.0	19.5	11.3	11.0	1.6	1.6	1.9	1.5	1.2	1.2	-	-
820721	0110	0910	WN	A	11.0	6.5	6.5	13.0	6.5	6.0	1.3	1.1	1.5	1.7	1.6	1.6	-	-
820721	0930	2030	WN	A	10.5	7.0	5.5	10.5	6.5	5.5	1.5	1.8	2.0	0.9	2.3	2.3	3.1	3.1
820722	2045	1000	WN	A	16.0	11.0	9.5	16.0	11.5	9.0	1.5	1.2	1.7	2.3	1.2	1.6	-	-
820723	1030	2000	WN	A	11.0	9.0	8.0	11.0	9.0	7.0	1.8	2.7	2.4	1.7	2.1	1.9	-	-
820726	0930	2030	WN	A	13.0	13.0	11.0	12.0	12.0	11.0	2.2	1.8	1.5	2.0	1.7	2.5	-	-
820727	0930	1945	WN	A	17.0	14.0	9.0	17.0	13.0	9.0	1.5	1.7	1.9	1.2	1.2	1.3	-	-
820728	0940	1945	WN	A	17.0	14.0	13.0	17.0	15.0	13.0	2.8	2.1	3.6	2.3	3.0	3.0	-	-
820729	1000	2030	WN	A	18.0	16.0	15.0	20.0	-	-	1.5	1.1	1.6	1.6	1.7	1.6	-	-
820730	0930	2015	WN	A	18.0	17.0	17.0	18.0	18.0	16.0	2.1	2.6	-	1.9	2.7	2.6	-	-
820426	1000	1215	EN	S	9.0	5.6	5.6	12.5	6.5	7.0	4.0	5.0	7.7	3.8	5.1	4.5	1.2	1.2
820426	1430	2000	EN	S	7.5	6.0	6.0	9.0	6.0	6.0	4.6	-	-	5.2	-	-	1.2	1.2
820426	2000	2200	EN	S	8.0	6.5	6.5	7.8	6.5	6.5	20.0	20.0	21.0	15.0	15.0	14.0	-	-
820426	2200	2400	EN	S	7.0	6.0	6.0	7.0	6.0	6.0	14.0	17.0	20.0	12.0	8.0	10.0	-	-
820427	0000	1000	EN	S	16.0	7.0	6.0	16.0	7.0	6.0	4.5	3.3	3.0	4.2	3.2	3.0	1.2	1.2
820506	1200	2000	EN	S	8.0	8.0	8.0	8.0	8.0	8.0	1.1	1.2	1.6	1.2	1.1	1.3	1.8	1.8
820506	2015	0015	EN	S	9.3	8.7	8.0	9.3	8.5	8.0	2.2	2.0	1.7	1.7	2.0	1.9	-	-
820507	0030	0915	EN	S	9.0	8.3	8.0	11.0	10.0	8.6	1.3	1.2	1.2	1.3	1.3	1.9	-	-
820507	0930	2000	EN	S	9.0	9.0	8.0	13.0	10.5	8.5	1.5	1.8	1.6	1.6	1.0	1.7	2.0	2.0
820507	2015	2215	EN	S	14.0	9.0	8.3	16.0	9.3	7.8	1.6	3.5	2.4	1.7	1.9	2.2	-	-

820507	2225	0025	EN	S	11.0	9.3	8.0	12.8	9.2	8.0	2.3	1.9	1.6	1.5	2.1	1.6	-	-
820511	1200	2330	EN	S	8.0	7.0	7.0	8.0	7.0	7.0	1.4	2.4	3.1	2.1	1.1	1.6	2.5	2.5
820511	2345	1230	EN	S	8.8	8.5	8.0	8.8	8.5	8.0	3.7	2.0	2.1	2.3	1.9	2.0	-	-
820513	2030	0930	EN	S	11.5	8.7	8.0	12.3	9.0	8.0	1.4	1.3	1.4	1.0	1.2	1.4	2.8	2.8
820514	0930	0000	EN	S	10.5	9.5	9.0	13.0	10.0	9.0	1.4	1.2	1.4	1.6	1.7	1.6	-	-
820518	1030	2230	EN	S	10.0	8.5	6.5	10.0	7.5	7.0	-	1.5	1.4	0.9	1.3	1.0	3.3	3.3
820525	1045	1415	EN	A	15.0	9.5	8.5	18.0	9.0	8.5	1.9	1.0	1.3	1.3	1.4	1.5	2.0	2.0
820525	1430	2000	EN	A	11.0	9.0	8.3	15.0	9.0	8.0	-	-	-	-	-	-	2.0	2.0
820527	1100	2000	EN	A	12.0	7.5	6.5	12.0	8.0	6.5	1.0	2.2	2.1	3.6	1.6	1.7	2.0	2.0
820602	1030	1420	EN	A	16.5	10.0	9.0	16.3	11.0	9.0	1.0	1.4	1.5	1.2	1.6	1.5	2.0	2.0
820602	1430	2030	EN	A	14.5	12.0	10.5	13.5	12.0	10.5	2.2	2.3	2.2	2.6	2.0	2.7	2.0	2.0
820603	1000	1345	EN	A	10.0	8.5	7.5	10.0	8.5	7.5	1.0	4.5	1.6	1.0	1.3	2.0	3.5	3.5
820603	1400	1930	EN	A	11.0	11.0	11.0	11.0	11.0	11.0	1.0	1.1	1.1	1.1	1.1	1.1	2.5	2.5
820608	1930	2130	EN	A	16.0	13.5	13.0	16.5	16.0	14.0	2.7	2.2	1.6	2.5	2.6	1.8	2.0	2.0
820608	2145	2345	EN	A	16.0	13.0	13.0	16.5	13.0	13.0	1.4	1.0	1.1	1.4	1.0	1.2	-	-
820609	0030	1000	EN	A	16.0	13.0	13.0	16.5	13.0	13.0	1.0	1.3	1.0	1.2	1.1	1.0	2.2	2.2
820610	1030	1345	EN	A	14.0	14.0	13.8	14.0	14.0	13.3	2.0	2.2	2.1	1.9	2.0	1.7	1.5	1.5
820610	1400	1945	EN	A	13.3	13.3	13.0	-	-	-	1.7	1.7	1.5	1.5	1.6	1.5	2.0	2.0
820610	2000	2200	EN	A	14.5	14.5	14.0	15.0	14.5	14.0	2.5	2.5	2.4	2.5	2.6	2.8	-	-
820610	2215	0030	EN	A	16.5	14.0	14.0	17.0	14.0	14.0	1.5	1.5	1.4	1.7	1.7	2.2	-	-
820611	0045	1400	EN	A	17.5	14.0	11.0	18.0	14.0	11.0	1.1	1.4	2.5	2.2	1.7	1.7	-	-
820611	1415	1945	EN	A	18.5	13.3	13.0	20.5	13.0	12.5	1.9	1.8	2.1	1.6	1.8	1.6	2.0	2.0
820611	2000	2200	EN	A	18.5	13.5	13.0	20.5	14.5	13.0	2.2	2.9	2.8	2.2	2.6	1.9	-	-
820615	1245	1000	EN	A	13.2	13.0	13.0	13.2	13.0	13.0	1.9	1.9	1.8	1.7	1.9	1.7	1.8	1.8
820616	1230	2000	EN	A	15.5	13.0	12.6	18.0	13.2	12.0	1.8	1.0	1.3	2.5	1.6	1.4	1.7	1.5
820616	2000	0100	EN	A	13.5	13.0	13.0	16.5	13.0	13.0	1.5	1.7	1.7	2.7	1.8	1.2	-	-
820617	0130	1330	EN	A	15.0	12.5	12.0	15.5	12.5	12.5	1.2	1.0	1.0	0.9	0.9	0.9	2.5	2.5
820617	1345	1930	EN	A	18.0	11.0	10.0	15.0	11.0	9.8	1.2	1.1	1.1	2.1	1.3	1.4	2.5	2.5
820617	1945	2200	EN	A	19.0	14.0	13.0	19.0	14.0	13.0	1.8	1.7	1.8	2.0	1.7	1.6	-	-
820617	2215	0945	EN	A	-	-	-	18.0	10.5	10.0	-	-	-	1.5	0.9	1.1	-	-
820623	2000	0000	EN	A	-	-	-	-	-	-	1.5	1.1	1.6	1.3	1.4	2.3	-	-
820624	0030	1000	EN	A	13.5	7.5	6.5	13.5	7.5	6.0	1.3	1.0	0.9	0.9	0.8	0.8	-	-
820624	2000	0930	EN	A	12.0	6.5	6.5	12.5	6.5	6.0	1.1	1.6	1.2	1.3	1.6	1.3	-	-
820625	1000	2000	EN	A	13.0	11.3	7.0	13.5	11.0	7.0	1.9	2.1	2.3	2.0	2.3	1.5	1.7	1.7
820625	2030	0930	EN	A	12.0	8.0	7.5	12.0	7.5	7.0	2.3	2.4	1.7	2.0	2.2	1.8	-	-
820628	2000	0015	EN	A	13.2	12.0	11.0	13.2	11.8	10.0	2.2	1.9	1.9	2.6	1.2	2.7	-	-
820629	0030	1000	EN	A	14.2	10.8	9.0	14.7	10.8	9.0	1.6	1.3	1.7	2.0	1.8	2.9	-	-
820629	1030	2000	EN	A	14.0	12.5	11.5	13.0	12.0	10.5	1.6	1.4	1.7	20.	1.7	1.5	-	-
820629	2015	2345	EN	A	11.0	8.5	8.0	13.2	10.2	8.2	1.9	2.3	1.9	1.9	2.3	2.1	-	-
820630	0000	1000	EN	A	9.2	7.8	7.2	9.2	7.8	7.3	1.6	1.5	1.7	1.7	1.7	1.4	-	-
820518	2245	0945	EU	S	12.0	11.0	9.0	12.0	10.5	8.5	1.6	1.5	1.7	1.6	1.9	1.9	-	-
820519	2130	1100	EU	S	16.5	11.3	10.2	15.0	11.0	10.0	1.3	1.2	0.9	1.1	1.0	1.0	-	-
820525	2020	2220	EU	A	11.0	9.0	8.3	15.0	9.0	8.3	2.3	2.4	2.5	2.2	2.2	3.1	-	-
820525	2245	0045	EU	A	14.0	8.8	8.3	13.0	9.0	9.0	1.7	1.4	1.7	1.8	1.7	1.9	-	-
820527	2015	2215	EU	A	12.0	12.0	9.0	11.5	11.5	8.5	1.9	1.9	1.5	1.8	1.9	1.6	-	-
820531	0930	1130	EU	A	14.0	11.0	11.0	14.0	12.0	11.0	1.0	1.6	1.0	1.7	1.8	1.7	2.8	2.5
820531	1140	1340	EU	A	18.0	13.0	11.5	18.5	11.8	11.8	1.6	1.4	1.4	1.5	1.6	1.5	3.0	2.5
820531	2015	2215	EU	A	17.0	11.0	11.0	20.0	11.0	11.0	1.5	1.7	2.4	1.6	2.3	2.5	-	-
820531	2230	0030	EU	A	17.0	11.0	11.0	19.0	11.0	11.0	1.0	1.5	1.3	1.2	1.6	2.6	-	-
820603	2000	2200	EU	A	14.0	12.0	12.0	13.0	12.5	11.5	1.4	1.0	1.5	1.1	1.1	1.2	-	-
820603	2230	2230	EU	A	11.5	11.5	11.5	11.5	11.5	11.5	2.0	1.7	1.4	2.0	1.2	1.6	-	-
820517	2215	2330	WU	S	10.0	8.3	7.0	10.5	8.3	7.0	1.0	1.5	1.6	0.8	1.3	1.6	-	-
820521	1030	2000	WU	S	8.5	7.5	7.0	8.5	7.5	7.0	-	2.3	1.6	-	1.7	1.7	3.0	-
820521	2015	0015	WU	S	10.3	10.3	10.3	10.3	10.0	10.0	2.3	2.4	2.2	1.6	2.4	1.9	-	-

820526	2015	2215	WU	A	15.0	12.0	8.0	15.0	10.0	8.0	1.4	1.5	1.7	1.3	1.5	1.3	-	-
820526	2230	0045	WU	A	14.0	8.3	8.0	14.5	8.3	7.3	1.6	1.6	1.3	1.5	1.6	1.7	-	-
820601	1945	2245	WU	A	14.0	11.0	11.0	14.0	10.5	10.5	1.0	1.6	1.2	1.7	1.9	3.1	-	-
820604	2015	2215	WU	A	12.0	11.5	11.5	14.0	12.0	12.0	1.5	2.1	2.3	1.5	2.0	2.1	-	-
820604	2245	0045	WU	A	12.0	11.0	11.0	13.0	11.5	11.0	1.6	1.2	1.2	1.6	1.3	1.3	-	-
820705	2000	0000	WS	A	11.0	11.0	10.0	10.0	12.0	10.0	2.1	1.8	1.8	2.1	2.0	1.8	-	-
820706	0015	0945	WS	A	13.5	10.5	10.5	13.5	12.5	11.0	2.1	1.3	2.4	1.6	1.6	3.9	-	-
820706	2015	0015	WS	A	16.0	15.5	14.5	16.0	15.5	15.0	0.7	0.9	1.2	0.7	0.9	1.5	-	-
820707	0030	0930	WS	A	18.0	15.0	13.0	19.0	15.5	14.0	1.2	1.5	2.1	0.8	0.4	1.5	-	-
820707	2015	0915	WS	A	12.0	8.5	7.5	14.0	8.5	8.0	2.8	3.2	2.6	2.0	1.9	2.5	-	-
820708	2030	0030	WS	A	14.0	9.0	9.0	14.0	9.0	9.0	1.6	1.4	1.8	1.7	1.3	1.6	-	-
820709	0045	0930	WS	A	9.0	9.0	9.0	9.0	9.0	9.0	1.6	1.8	1.9	2.1	1.6	1.9	-	-
820716	2000	0100	WS	A	19.0	17.0	9.0	19.0	17.0	10.0	1.9	2.1	2.4	2.4	2.0	1.3	-	-
820721	2045	0030	WS	A	9.0	8.0	8.0	17.5	6.5	6.5	6.3	1.9	1.9	1.9	1.5	2.5	-	-
820722	0045	0930	WS	A	12.5	8.0	7.0	12.8	7.5	7.0	1.4	0.8	1.1	1.0	1.0	0.9	-	-
820723	2100	0130	WS	A	17.0	14.5	14.0	17.0	15.5	14.0	1.5	1.4	1.0	1.2	1.5	1.8	-	-
820723	0200	1000	WS	A	15.5	13.0	12.5	16.0	13.5	12.5	1.4	1.1	1.3	1.2	0.9	1.1	-	-
820723	2000	0100	WS	A	10.0	15.0	17.0	11.5	14.5	17.0	1.6	1.9	1.6	1.2	1.7	1.8	-	-
820726	2045	0045	WS	A	16.0	16.0	15.5	15.0	15.0	13.5	2.3	3.7	2.6	2.8	2.6	3.0	-	-
820727	2000	0000	WS	A	17.0	17.0	16.0	17.0	17.0	16.0	1.2	1.7	1.6	1.4	1.9	2.3	-	-
820728	2000	0000	WS	A	18.0	16.0	16.0	19.0	17.0	17.0	3.1	5.1	3.0	2.2	3.8	3.7	-	-
820728	0030	0940	WS	A	-	-	-	17.0	17.0	16.0	1.4	1.1	1.6	0.8	1.6	2.2	-	-
820729	2045	0015	WS	A	19.0	16.0	16.0	20.0	16.0	16.0	0.9	1.3	1.7	1.0	1.3	1.4	-	-
820729	0015	0930	WS	A	18.0	17.0	17.0	19.0	17.0	17.0	3.1	3.1	1.3	3.0	3.1	2.6	-	-
820730	0030	0930	WS	A	18.0	16.5	16.5	18.5	17.0	17.0	1.8	1.2	1.7	1.1	1.5	1.5	-	-
820720	2030	0100	WS	A	18.0	17.0	14.0	21.0	17.0	15.0	2.0	1.9	4.5	2.7	2.0	2.2	-	-
820611	2215	0015	EN	A	18.5	13.5	13.0	19.5	15.0	13.0	1.5	1.3	1.2	1.3	1.8	1.4	-	-

REPLICATE

E - east

W - west

N - rope net

U - unsynchronized strobe and rope net

S - synchronized strobe and rope net

FISH

A - alewife

S - smelt

APPENDIX I

STROBE LIGHT OPERATION
FLICKERING DIVERSION STUDY, 1981

Date	Time	Deployment	Number of Functioning Strobes Top	Mid	Bottom	Experimental Meter Light Intensity (lux) Top	Mid	Bottom	Remarks
May 17	2215	WU	4	4	3	6.9	3.9	4.6	1.2 m. from barrier-calm
May 18	2245	EU	4	4	4	-	-	-	meter not functioning
May 19	2130	EU	4	4	4	3.0	7.3	-	0.6 m wave
May 21	1030	WU	2	4	1	-	-	-	meter not functioning
May 21	2015	WU	2	4	1	3	7.5	3	0.6 m wave
May 25	2020	EU	4	4	4	3	8.5	2.5	calm
May 25	2245	EU	4	4	4	3	8.5	2.5	calm
May 26	2015	WU	2	4	4	6	16.5	6.5	calm
May 26	2230	WU	2	4	4	6	16.5	6.5	calm
May 27	2015	EU	4	4	4	5.5	14.5	-	0.6 m wave
May 31	0930	EU	4	4	4	-	-	-	0.6 m wave
May 31	1140	EU	4	4	4	-	-	-	0.6 m wave
May 31	2015	EU	4	4	4	-	-	-	0.6 m wave
May 31	2230	EU	4	4	4	-	-	-	0.6 m wave
June 1	1945	WU	3	4	2	1	3	2	calm
June 3	2000	EU	2	2	2	3	4	7	0.3 m wave
June 3	2230	EU	2	2	2	4	4	7	0.3 m wave
June 4	2015	WU	2	2	2	4	5	8	0.6 m wave
June 4	2245	WU	2	2	2	4	5	8	0.6 m wave
July 5	2000	WS	2	4	3	-	-	-	meter not functioning
July 6	0915	WS	2	2	3	-	-	-	0.6 m wave
July 6	2015	WS	3	3	3	-	-	-	0.6 m wave
July 7	0830	WS	2	3	4	-	-	-	0.1 m chop
July 7	2015	WS	2	3	4	-	-	-	1.3 m swell
July 8	2030	WS	2	4	4	-	-	-	calm
July 9	0845	WS	2	4	4	-	-	-	calm
July 16	2000	WS	-	-	-	-	-	-	calm
July 20	2030	WS	-	-	-	-	-	-	calm
July 21	2045	WS	2	4	4	-	-	-	calm
July 22	3045	WS	2	4	4	-	-	-	calm
July 22	2100	WS	1	3	2	-	-	-	calm
July 23	0200	WS	-	-	-	-	-	-	calm
July 23	2000	WS	3	3	4	-	-	-	calm
July 24	2045	WS	2	4	4	-	-	-	calm
July 27	2000	WS	-	-	-	-	-	-	calm
July 28	2000	WS	3	0	1	-	-	-	calm
July 28	0030	WS	-	-	-	-	-	-	calm
July 29	2045	WS	3	3	3	-	-	-	calm
July 29	0015	WS	3	0	4	-	-	-	calm
July 30	0030	WS	2	2	3	-	-	-	1.0 m swell

E - East
W - West

U - unsynchronized strobe - rope net barrier
S - synchronized strobe - rope net barrier

APPENDIX E

STROBE LAMP DURATION (HOURS)
PICKERING DIVERSION STRUCTURE,1982

	East Strobes			West Strobes		
	Minimum (#Failed)	Maximum (#Functioning)	50% Failure	Minimum (#Failed)	Maximum (#Functioning)	50% Failure
Unsynchronized Strobes	43.5 (6)	47.5 (6)	43.5	16.5 (3)	31.8 (6)	27.8
Synchronized Strobes (July 5 - 9)	-	-	-	8 (3)	52.3 (9)	-
Synchronized Strobes (July 16 - 30)	-	-	-	14.5 (2)	86.3 (6)	68.8

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 501
JUNE 9 WEST STRUCTURE
ROPE NET NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 12	12 TO 19	19 TO 40
NONE OR FEW	0	0	0	0
FEW-PATCHY	0	0	0	0
LOW	0	0	0	0
MODERATE	0	0	0	0
HIGH	0	0	0	44
VERY HIGH	100	100	100	56

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 12	12 TO 19	19 TO 40
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	48	16	8	64
SHALLOW SLOPE TOWARDS	52	84	92	36
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	0	0

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	20
.04 TO .06	20
.06 TO .08	28
.08 TO .1	12
.1 TO .12	0
NO MOVEMENT OBSERVED	20

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT # 502
JUNE 11 WEST STRUCTURE
CONTROL DAY

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 12	12 TO 19	19 TO 40
NONE OR FEW	0	0	0	13.3333
FEW-PATCHY	0	26.6667	33.3333	20
LOW	0	13.3333	26.6667	6.66667
MODERATE	26.6667	20	13.3333	40
HIGH	60	33.3333	26.6667	20
VERY HIGH	13.3333	6.66667	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 12	12 TO 19	19 TO 40
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	20	13.3333
STATIONARY/PARALLEL	100	100	80	80
SHALLOW SLOPE TOWARDS	0	0	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	0	6.66667

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	100

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 503
JUNE 14 EAST STRUCTURE
CONTROL BAY

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	4.54545	13.6364	95.4546	100
FEW-PATCHY	63.4364	86.3636	4.54545	0
LOW	27.2727	0	0	0
MODERATE	4.54545	0	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	95.4546	95.4546	4.54545	0
SHALLOW SLOPE TOWARDS	0	0	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	4.54545	4.54545	95.4546	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	100

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 504
JUNE 14 EAST STRUCTURE
CONTROL NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	40.9091	100	100
FEW-PATCHY	0	0	0	0
LOW	100	59.0909	0	0
MODERATE	0	0	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	95.4546	100	0	0
SHALLOW SLOPE TOWARDS	4.54545	0	4.54545	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	95.4546	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	4.54545
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	95.4546

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 30S
JUNE 16 EAST STRUCTURE
ROPE NET DAY

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	65.2174	100	95.6522	100
FEW-PATCHY	26.087	0	4.34783	0
LOW	8.69565	0	0	0
MODERATE	0	0	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	4.34783	0	4.34783
ERRATIC: TOWARDS/AWAY	4.34783	0	0	0
STATIONARY/PARALLEL	13.0435	0	0	0
SHALLOW SLOPE TOWARDS	17.3913	0	4.34783	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	65.2174	95.6522	95.6522	95.6522

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	4.34783
.04 TO .06	8.69565
.06 TO .08	8.69565
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	78.2609

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 506
JUNE 16 EAST STRUCTURE
ROPE NET NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	39.1304	65.2174	73.913
FEW-PATCHY	0	0	0	0
LOW	86.9565	60.8696	34.7826	26.087
MODERATE	13.0435	0	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	4.34783	0	0	0
SHALLOW SLOPE TOWARDS	95.6522	60.8696	34.7826	26.087
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	39.1304	65.2174	73.913

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	39.1304
.04 TO .06	30.4348
.06 TO .08	21.7391
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	8.69565

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT # 307
JUNE 17 EAST STRUCTURE
ROPE NET DAY

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	0	25	100
FEW-PATCHY	8.33333	25	75	0
LOW	8.33333	58.3333	0	0
MODERATE	8.33333	16.6667	0	0
HIGH	66.6667	0	0	0
VERY HIGH	8.33333	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	100	100	75	8.33333
SHALLOW SLOPE TOWARDS	0	0	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	25	91.6667

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	100

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EIPERIMENTAL PARAMETERS
TRANSECT # 500
JUNE 17 EAST STRUCTURE
STROBES (200 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	38.8889	88.8889	100
FEW-PATCHY	0	11.1111	11.1111	0
LOW	66.6667	50	0	0
MODERATE	27.7778	0	0	0
HIGH	5.55556	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	94.4444	38.8889	5.55556	0
SHALLOW SLOPE TOWARDS	5.55556	27.7778	11.1111	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	33.3333	83.3333	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	5.55556
.06 TO .08	5.55556
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	88.8889

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT # 509
JUNE 30 WEST STRUCTURE
TEST RUN STROBES SYNCHRONIZED (105-240 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	14.2857	82.1429	96.4286
FEW-PATCHY	0	0	3.57143	3.57143
LOW	32.1429	71.4286	3.57143	0
MODERATE	57.1429	0	7.14286	0
HIGH	10.7143	14.2857	3.57143	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	42.8571	25	3.57143	0
ERRATIC: TOWARDS/AWAY	21.4286	21.4286	3.57143	0
STATIONARY/PARALLEL	28.5714	46.4286	10.7143	3.57143
SHALLOW SLOPE TOWARDS	7.14286	3.57143	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	3.57143	82.1429	96.4286

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	39.2857
.04 TO .06	35.7143
.06 TO .08	3.57143
.08 TO .1	3.57143
.1 TO .12	0
NO MOVEMENT OBSERVED	17.8571

APPENDII F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT # 510
JULY 5 WEST STRUCTURE
STROBES SYNC. (180 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

	DISTANCE FROM STRUCTURE IN METERS			
DESCRIPTION	0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	70.8333	83.3333	91.6667	100
FEW-PATCHY	0	0	0	0
LOW	29.1667	16.6667	8.33333	0
MODERATE	0	0	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY	DISTANCE FROM STRUCTURE IN METERS			
DESCRIPTION	0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	4.16667	4.16667	4.16667	4.16667
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	25	16.6667	8.33333	0
SHALLOW SLOPE TOWARDS	4.16667	0	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	66.6667	79.1667	87.5	95.8333

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	4.16667
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	4.16667
NO MOVEMENT OBSERVED	91.6667

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 511
JULY 13 WEST STRUCTURE
ROPE NET NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 45	15 TO 30
NONE OR FEW	5	35	75	100
FEW-PATCHY	50	35	10	0
LOW	20	5	15	0
MODERATE	20	20	0	0
HIGH	5	5	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	95	95	25	0
SHALLOW SLOPE TOWARDS	5	0	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	5	75	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	5
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	95

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 S12
JULY 14 WEST STRUCTURE
STROBES (180-240 FPM)-RIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	8	48	80
FEW-PATCHY	0	0	0	0
LOW	8	20	44	20
MODERATE	4	32	8	0
HIGH	36	28	0	0
VERY HIGH	52	12	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0-	0	4
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	96	88	44	24
SHALLOW SLOPE TOWARDS	0	0	0	0
HIGHLY SLOPED TOWARDS	0	4	0	0
VERY HIGHLY SLOPED TOWARDS	4	0	0	0
NO TRAJECTORY OBSERVED	0	8	56	72

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	100

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 513
JULY 19 WEST STRUCTURE
TEST RUN STROBES SYNC. (112-176 PPM)-HIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	60	75	90	95
FEW-PATCHY	25	5	5	5
LOW	0	5	0	0
MODERATE	10	10	0	0
HIGH	0	5	5	0
VERY HIGH	5	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC; TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	20	20	5	0
SHALLOW SLOPE TOWARDS	20	5	5	5
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	60	75	90	95

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	15
.06 TO .08	5
.08 TO .1	0
.1 TO .12	0
NO VELOCITY OBSERVED	80

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 314
JULY 20 WEST STRUCTURE
STROBES SYNC. 160-180 FPM-HIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	0	37.037	62.963
FEW-PATCHY	0	0	0	3.7037
LOW	0	33.3333	33.3333	22.2222
MODERATE	22.2222	23.9259	39.6296	11.1111
HIGH	44.4445	40.7407	0	0
VERY HIGH	33.3333	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	7.40741	7.40741	0
ERRATIC: TOWARDS/AWAY	3.7037	7.40741	18.5185	3.7037
STATIONARY/PARALLEL	48.1482	48.1482	18.5185	0
SHALLOW SLOPE TOWARDS	48.1482	37.037	48.7407	48.1482
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	14.8148	48.1482

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	11.1111
.04 TO .06	33.3333
.06 TO .08	7.40741
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	48.1482

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 315
JULY 21 WEST STRUCTURE
STROBES SYNC. 146-68 FPM-HIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	75	79.1667	91.6667	95.8333
FEW-PATCHY	4.16667	8.33333	4.16667	0
LOW	20.8333	12.5	4.16667	4.16667
MODERATE	0	0	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	12.5	4.16667	0	0
STATIONARY/PARALLEL	8.33333	8.33333	8.33333	4.16667
SHALLOW SLOPE TOWARDS	4.16667	8.33333	0	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	75	79.1667	91.6667	95.8333

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	4.16667
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	95.8333

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSEC" @ 516
JULY 22 WEST STRUCTURE
STROBES SYNC. (96-240 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	60.8696	65.2174	69.5652	86.9565
FEW-PATCHY	0	0	4.34783	8.69565
LOW	26.087	30.4348	26.087	4.34783
MODERATE	13.0435	4.34783	0	0
HIGH	0	0	0	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	0	0	4.34783	4.34783
SHALLOW SLOPE TOWARDS	39.1304	34.7826	26.087	8.69565
HIGHLY SLOPED TOWARDS	0	0	0	4.34783
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	60.8696	65.2174	69.5652	82.6087

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	8.69565
.06 TO .08	13.0435
.08 TO .1	17.3913
.1 TO .12	0
NO MOVEMENT OBSERVED	60.8696

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 517
JULY 23 WEST STRUCTURE
STROBES SYNC. (100 FPM)-HIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	20	64	80
FEW-PATCHY	4	4	0	0
LOW	36	36	16	12
MODERATE	24	12	16	8
HIGH	24	20	4	0
VERY HIGH	12	8	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	44	24	0	0
STATIONARY/PARALLEL	4	16	4	0
SHALLOW SLOPE TOWARDS	32	56	44	32
HIGHLY SLOPED TOWARDS	0	0	4	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	4	48	68

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	44
.04 TO .06	32
.06 TO .08	16
.08 TO .1	4
.1 TO .12	0
NO MOVEMENT OBSERVED	0

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 510
JULY 26 WEST STRUCTURE
STROBES SYNC. (180-220 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	0	8.33333	41.6667
FEW-PATCHY	0	12.5	41.6667	29.1667
LOW	8.33333	20.8333	16.6667	25
MODERATE	25	20.8333	33.3333	4.16667
HIGH	41.6667	33.3333	0	0
VERY HIGH	25	12.5	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	4.16667	0	0
STATIONARY/PARALLEL	100	45.8333	4.16667	0
SHALLOW SLOPE TOWARDS	0	45.8333	87.5	54.1667
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	4.16667	8.33333	45.8333

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	0
.06 TO .08	25
.08 TO .1	20.8333
.1 TO .12	0
NO MOVEMENT OBSERVED	50

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 319
JULY 27 WEST STRUCTURE
STROBES SYNC. (220 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	0	33.3333	70
FEW-PATCHY	0	3.33333	23.3333	20
LOW	0	13.3333	13.3333	6.66667
MODERATE	3.33333	30	23.3333	3.33333
HIGH	73.3333	53.3333	6.66667	0
VERY HIGH	23.3333	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	36.6667	26.6667	0	0
ERRATIC: TOWARDS/AWAY	10	26.6667	13.3333	0
STATIONARY/PARALLEL	43.3333	20	0	0
SHALLOW SLOPE TOWARDS	10	26.6667	53.3333	30
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	33.3333	70

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	0
.04 TO .06	56.6667
.06 TO .08	20
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	23.3333

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 320
JULY 20 WEST STRUCTURE
STROBES SYNC. (180-455 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	3.57143	78.5714	100
FEW-PATCHY	0	3.57143	0	0
LOW	7.14286	50	21.4286	0
MODERATE	42.8571	39.2857	0	0
HIGH	46.4286	3.57143	0	0
VERY HIGH	3.57143	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	10.7143	0	0	0
STATIONARY/PARALLEL	46.4286	35.7143	14.2857	0
SHALLOW SLOPE TOWARDS	42.8571	60.7143	7.14286	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	3.57143	78.5714	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	7.14286
.04 TO .06	21.4286
.06 TO .08	39.2857
.08 TO .1	7.14286
.1 TO .12	0
NO MOVEMENT OBSERVED	25

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT 0 321
JULY 29 WEST STRUCTURE
STROBES SYNC. (180-455)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	36.6667	20	30	100
FEW-PATCHY	3.33333	10	13.3333	0
LOW	50	56.6667	53.3333	0
MODERATE	3.33333	10	0	0
HIGH	6.66667	3.33333	3.33333	0
VERY HIGH	0	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	3.33333	0	0	0
ERRATIC: TOWARDS/AWAY	76.6667	80	56.6667	0
STATIONARY/PARALLEL	0	3.33333	3.33333	0
SHALLOW SLOPE TOWARDS	16.6667	13.3333	23.3333	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	3.33333	3.33333	16.6667	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	23.3333
.04 TO .06	43.3333
.06 TO .08	16.6667
.08 TO .1	10
.1 TO .12	0
NO MOVEMENT OBSERVED	3.33333

APPENDII F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

EXPERIMENTAL PARAMETERS
TRANSECT # 522
JULY 30 WEST STRUCTURE
STROBES SYNC. (215-455 FPM)-NIGHT

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	0	0	83.3333	100
FEW-PATCHY	0	0	16.6667	0
LOW	0	83.3333	0	0
MODERATE	0	16.6667	0	0
HIGH	66.6667	0	0	0
VERY HIGH	33.3333	0	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM STRUCTURE IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM STRUCTURE	0	0	0	0
ERRATIC: TOWARDS/AWAY	0	0	0	0
STATIONARY/PARALLEL	66.6667	50	0	0
SHALLOW SLOPE TOWARDS	33.3333	50	16.6667	0
HIGHLY SLOPED TOWARDS	0	0	0	0
VERY HIGHLY SLOPED TOWARDS	0	0	0	0
NO TRAJECTORY OBSERVED	0	0	83.3333	100

OBSERVED VELOCITIES OF FISH (TOWARDS STRUCTURE)

RANGE (m/sec)	PERCENT FREQUENCY OF OBSERVATION
0 TO .02	0
.02 TO .04	50
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	50

APPENDIX F

PICKERING DIVERSION STUDY, 1982
ACOUSTIC MONITORING: FISH DATA SUMMARIES

SYNCHRONIZED STROBES COMBINED DATA

OBSERVED FISH DENSITY DATA

DESCRIPTION	DISTANCE FROM BARRIER IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
NONE OR FEW	22.5564	25.5639	54.8872	82.3308
FEW-PATCHY	1.1278	4.1353	9.0225	6.0150
LOW	18.0451	30.8271	23.6842	9.0226
MODERATE	13.5338	18.0451	10.9023	2.6316
HIGH	29.3233	18.4211	1.5037	0
VERY HIGH	15.4135	3.0075	0	0

OBSERVED FISH TRAJECTORY DATA

TRAJECTORY DESCRIPTION	DISTANCE FROM BARRIER IN METERS 0 TO 5	5 TO 10	10 TO 15	15 TO 30
AWAY FROM BARRIER	4.8872	4.1353	1.1278	0.7519
ERRATIC:TOWARDS/AWAY	16.5441	15.7895	9.7744	0.3759
PARALLEL/STATIONARY	37.594	28.5714	10.5326	3.0075
SHALLOW SLOPE TOWARDS	22.1805	28.9474	28.1955	16.9173
HIGHLY SLOPED TOWARDS	0	0.3759	0.3759	0.3759
VERY HIGHLY SLOPED TOWARDS	0.3759	0	0	0
NO TRAJECTORY OBSERVED	18.4211	22.1805	50	78.5714

OBSERVED VELOCITIES OF FISH (TOWARDS BARRIER)

RANGE (M/SEC)	PERCENT FREQUENCY OF OBSERVATION
0 TO 0.2	0
.02 TO .04	50
.04 TO .06	0
.06 TO .08	0
.08 TO .1	0
.1 TO .12	0
NO MOVEMENT OBSERVED	50

POOR

QUALITY

ORIGINAL